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Teaching the Machine Grammar

It was felt that the readers of BABEL would be interested in a picture, however sketchy, of the work which is being done in the field of mechanized translation in the Italian Operational School, headed by Silvio Ceccato and Enrico Maretti; the originality of their approach to the problem induced the organizers of the "Third London Symposium on Information Theory" to invite them to discuss their results, and it is from the notes of that report and some other of Ceccato's writings that this article has been prepared by M. V. Heberden who is well-known as a writer and is also an active member of the Italian Association of Translators and Interpreters.

Obviously this is an oversimplification of what has to be done to "teach" a machine to translate. However, it broadly conveys the fundamental idea of the difference between a bi-lingual mechanized dictionary and a translating machine. It is a difference which can be appreciated by any layman who has toured in some country where he did not know the language, optimistically equipped with a vocabulary guaranteed to provide "all the tourist needs". The approach by *Silvio Ceccato* and *Enrico Maretti* to mechanized translation is based on a study and demonstration of activities of which speech is the expression. One of the main obstacles has been the lack of a description (in terms usable for the planning and design of mechanism) of man's mental activities.

The Italian Operational School which Silvio Ceccato represents and where he and the engineer Enrico Maretti have been carrying out this work is an organization which is developing "operational research" in Italy, that is to say, scientific methods applied to the use of manpower and equipment.

The way in which Ceccato and Maretti are tackling the problem, and their approach to it, is radically different from any that, to the best of our knowledge, is being used by others engaged in similar projects.

The solution of some of their major difficulties has required excursions into the theory of speech, of language and of communication; obviously without a thorough grasp of how we communicate and the theory of the mechanics of the human brain in regard to communication, we can hardly expect to "teach" the task to the machine. This leads to questions as to the *raison d'être* of semantics, why they are needed and how they have developed or, in words of one syllable, how the various tribes of the world have arrived at expressing "things" or nouns, "states of action", "metamorphoses" etcetera, correlated one with the other by a series of rules and then, by extension, at the understanding of psychical and metaphysical concepts, frequently with the use of the same "words" or rather the same sounds or graphic symbols having a different meaning.

The understanding and operational description of all these processes lead also to an understanding of how easy it is for the machine to make mistakes. It could, for example, fall into the errors which all human translators know by heart, ranging from the famous boner of "Il Gallo morente" which some bright French translator rendered as "Le Coq mourant" to others which might more plausibly cause difficulties to tyro-translators such as the Italian word "cane" which means in English both "dog" and "hammer (of a gun)". From the latter there are endless possibilities for strange linguistic hashes to come forth; we might have the "dog that did not trip as it should" and "the hammer that barked all night". We know from the context that in the latter sentence "dog" is the word to use, because we know that hammers don't usually bark in the night, nor in the day, for

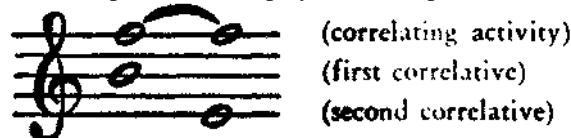
that matter. We know it. How do we know it? We don't think of it consciously. We have jumped the gap and put the word *dog* without realizing that we were doing it — without even realizing that there was a gap. This is a simple example of the mental activity which is sometimes termed correlation.

CORRELATION

Anything we are or that we understand, we are or understand in relation to something else; therefore, if we have no reality unless we are related to something else, the "something else" equally has no reality unless related either to us or another thing. If it is the relation which confers reality on the thing, obviously the relation is of paramount importance.

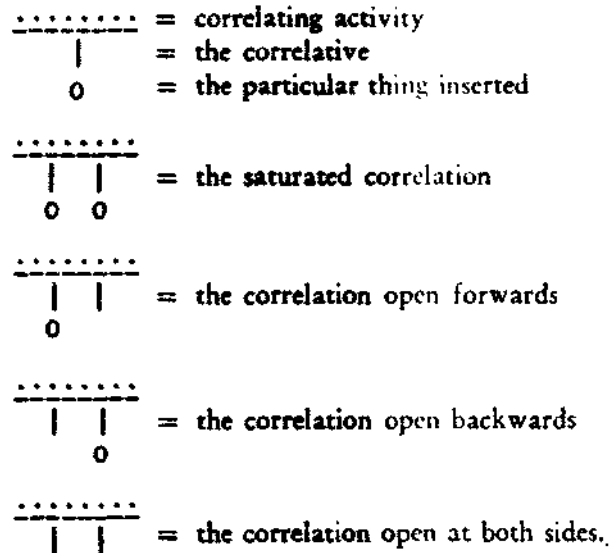
The correlation which is the difference between a series of irrelevant sounds and music might be compared to the correlation which is the difference between sounds and coherent speech.

In music, the correlation itself can be presented as a play of counterpoint and duration.



The longest is termed correlating activity in as much as, starting from the other two isolated things, the correlation is arrived at through it.

If we then consider the question of inserting this or that particular thing in the place of one or the other of the correlatives, using the word insert as "synchronize", we can also use the terms "first place" and "second place" of a correlation. Now, when there is a correlation with both of the place occupied, it may be called a "saturated correlation" and when only one of the two places is occupied, it is a correlation "open backwards" or "open forwards" as the case may be, or open on both sides, when neither place is taken.



This is simple correlation with a construction of three pieces, the minimum nucleus liable to correlation. The construction is widened when one of these minimum nuclei is wholly or in part a correlative of another correlation. Then we have multiple correlation.

A knowledge of these correlations is necessary for an understanding of how a language is made. And by *made* is meant starting from scratch, not putting together words and conceptions borrowed from languages already existing. Without them, each individual correlation between things, things used as words, things named, simple and multiple, would require a different sound symbol or combination of sound symbols, so that the greatest mental giant would hardly manage to express himself as well as a baby or a savage; so our speech traffic rules, or shorthand or formulas or whatever we like to call them, have endured so that with a minimum of sounds (as the few hundred notes of music were sufficient for Mendelssohn and Chopin, Wagner and Gershwin with the aid of correlation and the minimum of sounds which comprise an alphabet when combined into words suffice for Kant and Margaret Mitchell), we can express a practically unlimited number of things, happenings and concepts. The keystone of all these structures is correlation. Hence the machine has got to be taught first and always to correlate.

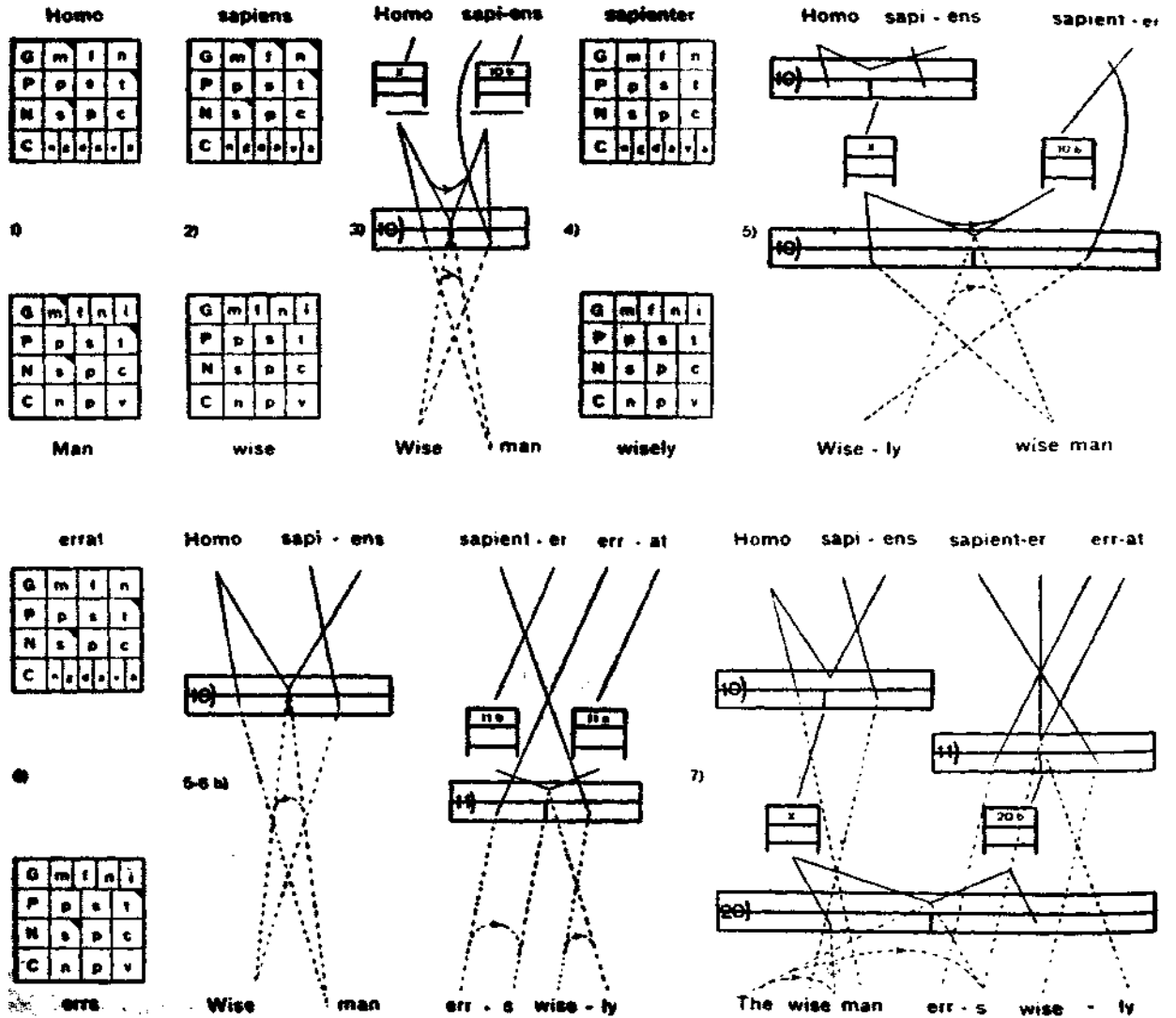
So, to return to our “dog which doesn’t trip” and the “hammer which barks at night”, the machine must seek in the context what subject is being talked about — animals or guns, which means a given number of cards or symbols and then it has only begun its work; since it is quite possible to have a sentence which includes both the domestic animal and the weapon, the machine then has to do more correlating to decide where the correlatives belong. And still it is only on the first lap of its work. It is now equipped with a little card with a series of references which tell it whether the dog or the gun hammer is in order, but then it has to begin “thinking” whether the noun is nominative, dative or accusative (or indirect or direct object, if you prefer), and before it can do this, it has to have the “activating” word, i.e. the verb. Verbs in the various languages have unfortunate habits of taking after them, arbitrarily, certain determined prepositions. French is troublesome; Spanish, Italian and Portuguese are complicated but reasonably logical, Latin has the great virtue of almost invariably following the rules and English contains an alarming percentage of exceptions. So, ask Messrs. Ceccato and Maretta, what do we do to try to “teach” our poor machine so that it does not have a bad attack of mental indigestion?

The figure on the opposite page shows something which is relatively simple. Please note the word “relatively”, for though it appears to be a straightforward sentence, there is the possibility of linking “sapienter” either with “sapiens” — “Homo sapiens-sapienter errat” — or with “errat” — “Homo sapiens sapienter-errat”. Both versions make sense and signify different things. At this point the frequency card goes into action. This says: “in the case of having to link an adverb with a verb or non-verb, the adverb more frequently modifies the verb”.

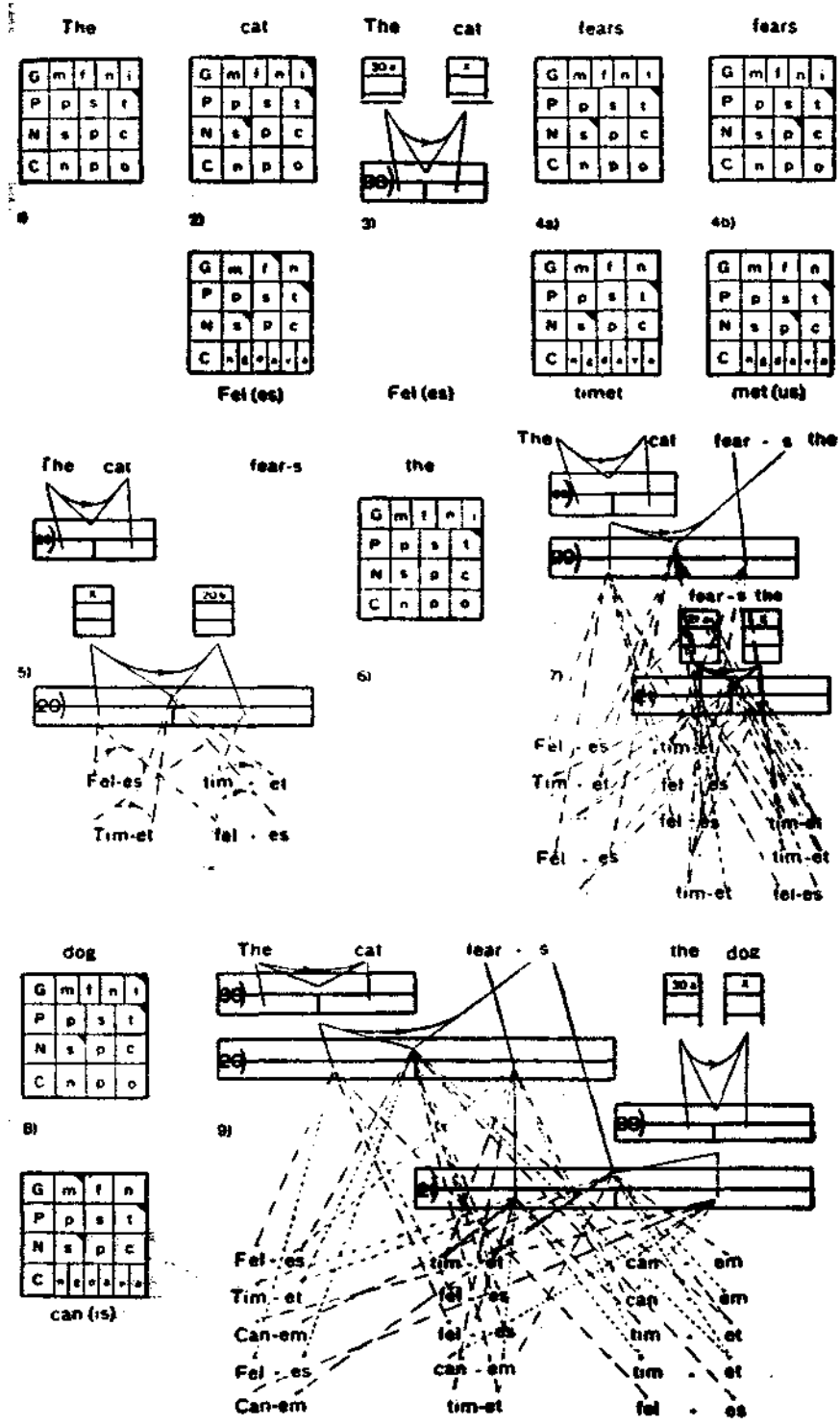
The Italian Operational School is in the process of collecting all the correlations in use in English, Italian and Latin, distinguished according to the different correlating activities presented in them. Correlations in themselves are common to the input and output languages, but the verbal manner of presenting them is anything but!

Added to these difficulties and to the question of the multi-meaning words on which we already touched, there are other hurdles in the way such as ambiguity in the original language and a more serious one which is met when the word in the original language is without a counterpart in the language of arrival because the people of the second language are unaware of the existence of the thing or the concept. Where the word designates something material such as, let us say, a hat, this could be described to a tribe which had never seen or heard of a hat provided there were counterparts in their language for words such as “round”, “straw” or “felt”, phrases such as “to wear on the head”, “protect from the sun and rain” and so on; with the aid of these terms, the tribe might

be induced to picture something more or less resembling a hat. But where something less tangible and more complicated is concerned, such as art or economics, if a counterpart does not exist in the other languages, the machine can hardly give them out as "activities of man". Undoubtedly they are, but the person receiving the communication might quite justifiably "understand" war instead of art, and we could not accuse him of being mistaken; unfortunately war is another of the activities of man.



Example of a translation from Latin into English. There are three correlations in play: 1) the correlation of substance-accident, of the substantive-adjective type, here given number 10; 2) the substance-accident correlation of the occurrence-modality type, marked with no. 11; and 3) the subject occurrence correlation, indicated by no. 20. The example also shows a case of a construction which is torn down, that is to say the double significance of "homo" which, when "errat" appears, comes underneath in two distinct specifications, following a rule of greater and lesser frequency.



Example of translation into Latin of an English sentence: "The cat fears the dog." Two correlations come into play in both the languages: 1) the subject-occurrence correlation, which is given here as no. 20; the occurrence-object correlation which is marked as no. 21. A third correlation is present, but only in the English language, that of the presenter-presented, in those cases where the presenter is the definite article, which has been given here the number 30.

Even in the two languages which up to now we have been considering, English and Latin, while we do not find such distressing absences of counterparts, we do run into the structural differences of the grammars; to quote the most obvious, three cases in English and six in Latin. To cope with this, Maretti has furnished the machine with little concordance cards which it has to fill in.

On the opposite page there is another example, this time of the translation of the English sentence “the cat fears the dog” into Latin.

Here, apart from correlating and concurring to decide whether cat, which is written the same in the nominative and accusative cases in English shall be “feles” or “felem” and making a similar decision concerning dog, there is a decision to be made concerning “fears”. It is a multi-meaning word and the concordance card can be filled in two ways; first: “verb — third person — singular”; second: “third person — plural — nominative or accusative”. Correlate! And the machine finds that it is only possible to correlate with “fears” according to the first signification.

It is hoped that this brief article on some of the aspects of the contribution to mechanized translation which is being made by the Italian Operational School will serve to outline the approach by Ceccato and his colleagues to the major difficulty — a solution which frankly faces the fact that a machine which cannot think can never accomplish all the work which a human translator can but which can reproduce the work of correlation, so that *Adam II*, as they have named their machine, can not only handle words but also the relationship of words in speech. At present, *Adam II* can cope with the following operational instructions: something, object, subject, singular, plural, beginning, end, all, same, other, space, time, and, or, nothing, development, subject of development, object of development, comparison, concept, particular, equal, different. And to us, this seems no mean feat on the part of *Adam II*.

References:

¹⁾ Y. Bar-Hillel: “Can Translation be Mechanized” — *Methodos* Vol. VII, No 25—26 (1955).

²⁾ CECCATO, S.: La grammatica insegnata alle macchine. *Civiltà delle Macchine*. Nos 1 and 2 (1956).