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Thought as the Basis of Mechanical Translation and Summarising

Silvio Ceccato

Centro di Cibernetica e di Attività Linguistiche
Milano
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The Centro di Cibernetica e di Attivita Linguistiche (Milan University) has worked for some time on the mechanisation of several linguistic phenomena. This research is the continuation and the direct result of earlier studies in three different fields:

1) Analysis of thought and its contents in terms of operations;
2) Isolation of the conventional connections between thought and language;
3) Construction of mechanical models capable of imitating the operations involved in observation, mental categorisation, thought and language.

The linguistic phenomena that, so far, have been closely examined with a view to their mechanisation are: a) translation and b) the description of perceptual situations.

Some research, however, has also been directed towards the activity usually referred to as Summarising; and it is this research in particular which prompted us to take part in this discussion of the subject of documentation.

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To begin with I should like to indicate the general direction in which the "Centro" pursues its research on linguistic matters.

The point of departure is for us the observation that thought proceeds by correlation, that is to say, by opening and closing correlations. In order to correlate we give a particular temporal order to three things, at
least one of which is a mental category containing a relation. Put precisely, this mental category is applied first to one thing and afterwards to another. In doing this the first thing to which the mental category is applied becomes the first correlatum of the correlation, and the second thing becomes the second correlatum, while the mental category becomes the correlator of the correlation.

It is not difficult to individuate this characteristic structure of thought, if one "thinks" for example of what is expressed by "Italy and France": if you were to stop at "Italy and" you would already have applied the mental category designated by "and" to "Italy", and by doing so you would have opened the correlation; but the mental category would still have to be applied to "France" in order to close the correlation and thus complete the thought. Closer attention is required to individuate the same structure when the mental category is not designated by an isolated word of its own, but for instance by the sequence of the words that designate the correlata, or by the form of these words, as is the case in expressions like "John runs" or "handsome John". However, in these cases also it is not very difficult to realise that one sets up a relation between the two things by maintaining the first while the second one is added and becomes "its" activity, quality, etc.

Of course our thoughts are hardly ever limited to a single correlation, but proceed according to more or less intricate nets of correlations in which the single correlations figure as correlata and correlators of larger
correlations. For example in the sentence "John runs and
jumps" the correlation "runs and jumps" forms the second
correlatum of the correlation whose first correlatum is
"John".

Once we had become aware of the correlational
structure of thought, we were able also to isolate the
indications which any form of thought must contain if it
is to designate a minimum unit of thought, that is to say
a correlation. We quickly discovered that the minimum
number of indications is five and that these indications
are of two kinds.

Three indications are required to express the
three particular things that constitute the correlation;
we call them correlanda. They could be "fish", "or",
"fowl"; or they could be "to love" followed by "John";
or "beautiful", "but", "poor"; or again, "for", "and",
"against", etc. In fact, as correlata there can be
anything whatever of the observational or mental kind,
and as correlator any one of the mental categories that
contain a relation. But these three indications do not
yet tell us which correlational function is to be assigned
to each of the single things in constituting the correlation;
that is to say, whether they are to be used as correlator
or as first or second correlatum. In fact, even the
relational mental categories may at times function as
correlata and not as correlators, for instance in a case
like "and and or are relations". Hence the expression
of a correlation must contain at least two more indications:
one to assure us that the particular relational mental
category is to be used as correlator (which enables us to deduce that the two other things indicated must be used as correlata), and the other one to tell us the place of one of the correlata (from which we can infer the place of the other correlatum).

One kind of indication, therefore, designates the particular correlanda, another kind their correlational function. Given these indications, it is always possible to establish a correspondence between thought and language; and thus it becomes intelligible how language in general - i.e. sounds, graphic signs, pauses, and sequence - has become "semantic" and can be studied as such in its counterpart which is thought.

In the ordinary use of language, however, the situation is rather more complicated. Certain relations between things are introduced quite independently of their explicit assertion; that is to say, the mere mentioning of certain things may be sufficient for us to put them in relation, because the general, previous knowledge we have of these things establishes the relations for us. Therefore it can happen that a speaker not only refrains from giving certain indications, but even goes so far as to use a linguistic expression expecting it to be interpreted notionally in a way that goes against the particular semantic conventions that obtain for the expression used.

Here are two examples to illustrate this. In the sentence "In a deckchair, worn and depressed, there
sated a young woman" the phrase "worn and depressed" could, according to its place and its grammatical form, refer either to the deck-chair or to the young woman. But the listener will have no doubts; only the woman could be happy or depressed, not the deck-chair; and thus there is no hesitation about the choice. But the choice is made precisely on the basis of that general, previous knowledge which we mentioned before, and on which the speaker relies.

In a sentence like "a house for a large family with garden" (which might easily occur in colloquial English) the notional interpretation overrides the semantic interpretation indicated by the rules of sequence. These conventional rules would lead us to relate "garden" to "large family"; but here too, the general, previous knowledge of the things involved prompts us to connect "garden" with "house" rather than with "large family".

Traditional linguistics has tried to cope with this situation, which arises, for instance, with prepositions and with the cases, by attributing more than one significance to each of them. As a result we have for instance a "with" of company, a "with" of modality, a causal "with", etc. But analysis of the relational mental categories designated by prepositions shows that, in fact, it is not so. "With", for example, always and quite simply designates the dual presentation of something that has previously been seen as as one piece. In an expression like "beating with a hammer" the designation of the instrument does not derive from the "with", but from the
knowledge we all have of "beating" and of "hammer". In "sitting with crossed arms" the designation of the modality derives in the same way from what we already know of "sitting" and of "crossed arms"; in "Mary and John" the designation of company derives from what we know about human beings; in "he trembled with fear" the designation of the cause is derived from what we know about "tremble" and "fear"; etc. Similarly (to give another example) with the proposition "of", which designates nothing but the dual presentation of something that has, previously, been seen as two pieces, one can put in relation the most varied kinds of thing, leaving it to their particular characteristics to specify a particular relation. Thus we can say equally well "that new car of Ford's" and "that new car of Mr. Brown's" and every Englishman will understand that in the first case one refers to a make, because Ford is a car factory, and in the second case to property, because Mr. Brown is another kind of thing.

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As a rough estimate one can say that, above all in certain kinds of everyday usage, we add to the indications supplied by language some thirty percent of further indications, which are derived sometimes from general knowledge and sometimes from our representations of the nominata. It is on account of these indications that certain relations are established between certain things and that certain things are put in certain relations -
at times, as we have seen, even in opposition to the linguistic indications.

Hitherto linguistic research has considered this problem so unimportant that it does not even figure among the chapters of linguistic textbooks. As a rule it is, of course, admitted that for a non-philosopher or a non-mathematician, for example, it is not sufficient to know the language in which a philosophical or mathematical text is written, in order to understand it. But it is precisely because current language presupposes a common knowledge, i.e. a knowledge that is within everybody's reach, that there is no need to devote a special chapter to this problem in any particular discipline.

The situation, however, is rather different if one considers a linguistic machine, which has no knowledge of this kind at its disposal; the same applies to anyone who sets out to build a linguistic machine; a considerable part of his work will necessarily consist in making himself aware of all that acquired and presupposed knowledge which is continually being drawn upon by anyone who speaks; and he will have to make himself equally aware of the representations and, with them, also of the entire gamut of operations which words stimulate and contribute to the comprehension of a discourse.

A great many results which can be used towards this end have been obtained by the Centro di Cibernetica during research work on thought and, in particular, during research that no longer concerned only the correlational
structure of thought, but also the composition of the particular correlanda, or in other words the contents of thought.

Analysis in operational terms has shown that the contents can be reduced to three kinds of operation or combination of operations.

One kind is Differentiation. From it we get the differentiata, e.g. light and dark, hot and cold, noise and silence, the various colours, flavours, etc. These differentiata, of course, are not yet localised, either in time or in space, nor do they appear with a shape or a category — for instance, black does not appear as a spot, as singular or plural, as a substance or as a property, etc.

Categorisation i. e. and figuration are the other two kinds of operation to which we owe the contents of thought.

Categorisation is carried out by means of moments and their combinations; these combinations are temporal traces which, again, can be combined with each other or with other moments. The moments are produced by means of a temporal structure obtained by the alternation of states of presence and states of absence (or consciousness and unconsciousness, or attention and disattention). The alternation of two states generates the plurality of moments and characterises them in two different ways:

a) as moments occupying a particular moment in the general sequence,
b) as moments that are being maintained, or kept present, in coincidence with the states of presence, and as moments that are being left, in coincidence with the states of absence.

In categorial combinations the moments of presence are used according to a general scheme which we shall set out below.

Figuration is carried out by means of places and their combinations; these combinations are spatial traces which, again, can be combined with each other giving rise to composite traces, or to regions or zones, or, finally, to composite regions or volumes. The places are produced by a spatial structure which has been obtained by the alternation of states of presence and states of absence (or attention and inattention, or consciousness and unconsciousness). The alternation of the two states generates the plurality of places and characterises them:

a) as places that are being maintained, or kept present, in coincidence with the state of presence,

b) as places that are being left, in coincidence with the state of absence; and at the same time,

c) the passing from one place to another, either by means of motion and its direction or by means of rest (absence of motion), assigns to them a particular place in the structure.
In figurational combinations the places of presence are used according to a general scheme which we shall set out below.

Both temporal and spatial combinations are made after the completion of the combinanda, and in the following way: the piece that is made first is stored in the memory; the piece that is made subsequently is maintained while the stored piece is taken up again so that it comes to be temporally superposed on the maintained piece; the procedure is similar to the bringing forward of a running total in accounts.

Among the mental categories we find: something, object, subject, singular, plural, collective, space, time, cause, effect, probable, determinate, accident, state, process, always, never, continuous, discontinuous, and, or, with, but, number, point, line, etc.

The thing indicated by "something", for instance, corresponds to the very simplest combination of moments: a first moment of presence is stored, a second moment of presence is maintained, and the temporal superposition of the two is obtained by taking up the stored moment.

The number of figures is practically unlimited if one takes into account all the ways in which they can be characterised.

The sequence of operations that constitutes a figure comes out very clearly if, for instance, we consider this design.
first as a parallelogram, then as a rhomb, and then as a square. Or, to give another example, if we consider the following design

first as the point of an arrow (the two traces seen as converging)

and then as a handle (the two traces seen as consecutive)

Having become aware of these operations it became possible to think of building a linguistic machine that might operate in the same way as man does. Relevant research, as we have seen, has so far been carried out in two main directions: towards a machine that translates, i.e. substitutes for the expressions of one language those of another, leaving as nearly as possible unchanged the thought expressed by the original; and towards a machine that describes what it sees, i.e. that substitutes a linguistic situation for a perceptual situation.
Given that we wished to obtain results of some practical value, mechanical translation seemed to be the more favourable project. Here, in fact, it is not a question of inserting between the input language and the output language the entire sequence of hitherto uncharted operations which, in man, follows upon hearing someone speak or precedes one's own speaking. And if language to a large extent provides the indications necessary for passing to the designated thought (by means of the form and the sequence of words), operational analysis needs to supply only the remainder of the indications necessary for us to complete the sequence of our operations. Besides, this analysis does not always have to be carried to the point where the single nominata are articulated into their operational atoms, as would be necessary in the case of a machine that observes and describes. And, finally, the operations that have been individuated do not have to be actually carried out (as in the case of the observing machine); it will suffice to indicate them according to some code.

Thus we accepted the task of analysing (on behalf of the US Air Force) first a vocabulary of some 15,000 Russian words, and now a larger vocabulary of some 50,000 Russian words. From these analyses we obtain the indications that are necessary for a machine to construct the correlational nets corresponding to the trains of thought that may be designated by any discourse made up of the words included in the vocabulary; and the correlational nets are then to be expressed in the English language.

There are, for example, the classifications that indicate the possible correlational functions of the words,
and the specific character of the correlations as a function either of the correlator (as an individual) or of the correlata (mostly as classes, but sometimes also as individuals).

The vivid experiences stimulated by words, when we understand a discourse, and above all the representations they evoke, contribute in two different ways: firstly by indicating the operations - in the form of atoms or composites - that are constitutive of the single nominata, so that the machine can use the implications subsisting among them owing to the presence of certain operations of one nominatum in the constitution of another; secondly by indicating in what relation certain things are usually put owing to our general practical experience.

There are, of course, also the usual classifications for grammatical agreement, for frequency in the case of several significations, etc. Altogether there are about a thousand classifications divided into some thirty groups.

Apart from the output in English, included in the original project, we are now adding also Italian and German output (on behalf of EURATOM).

In the course of these enquiries we became more and more conscious of the fact that the essential step in any linguistic study is the step towards thought. Thought is the indispensable bridge when discourse in one language is linked to discourse in another as translation, and also when discourse is linked to an observational situation, as its description. There could, however, be foreseen two other cases where the analysis of thought would prove even more operative: when one discourse is linked to another discourse for the purpose of transformation, that is to say, for the purpose of summarising or of extending and developing it.

Although research in these directions has so far
been only sporadic and not determined by a particular pro-
ject, we have gathered sufficient material to indicate at
least the two major operational paths involved in the ac-
tivity we call summarising.

The first consists in maintaining only those parts
of a train of thought that have been present for a longer
time than the others while one was gathering the meaning of
the text to be summarised, and letting drop those that have
been present for a shorter time. This criterion of duration
of presence can, of course, vary according to the number of
things one intends to maintain; and thus, if one sole thing
is to be kept it will be the one that was present during
the operating for a longer time than any other. This kind
of summarising, based on the duration of presence in the
course of the thought process, is employed continually by
us, for instance when we summarise observational situations
which, in their actual occurrence, took a longer time than
we have at our disposal for their description; this method,
further, does not require any particular reference to pre-
vious learning, and we are, therefore, always able to use it.

To understand the functioning of this rule of prun-
ing, of suppression, it is sufficient to remember thought
proceeds in a correlational net of polyphonic form, which
assigns longer or shorter times of presence to the indi-
vidual pieces of thought content.

Applied in practice, this method would work, for
instance, in the following way: the complement (in a sen-
tence) disappears, while that which is complemented re-
mains; the specification disappears, while that which is
specified remains; the development (i.e. the thing designat-
ed by the verb) disappears, while the subject remains; the
accident disappears, while the substance remains; and so
forth, unless the complement, the specification, the de-
velopment, etc., are not in turn complemented and receive,
therefore, a relatively longer time of presence. Hence "a servant of the Queen" becomes "a servant", but "a servant of the Queen of England", in the first cycle of elimination, becomes "a servant of the Queen".

Naturally the time of presence certain things occupy in a discourse will not be reflected in all cases by the recurrence of certain words; and therefore one will have to resort to actual operating, not only with regard to the correlations that are characteristic of thought, but also where the content of thought is concerned. For instance a pronoun, which always remains the same word, can refer to any number of different things in different contexts.

Reduction according to the duration of presence must, however, be regulated by at least two criteria. One of these concerns the percentage that is to be suppressed, the other a possible preference by which one might want to determine a choice between elements having the same duration of presence, or even decisions against the criterion of duration; these criteria, of course, have to be established according to the particular interest of the summariser (just as a text can be read once in order to glean from it a particular kind of information, and a second time for another kind of information).

The second operational path involved in summarising resorts more frequently to a particular kind of knowledge: implication and generalisation. In the first case, if an implicant is named as well as the thing implied by it, the implicant will be sufficient to represent the entire situation. Thus a sentence like "the family owned a piece of land planted with apple trees, pear trees, and cherry trees" could become "the family owned apple trees, pear trees, and cherry trees"; in this way one avoids talking of the piece of land as well as of planting, because it is known that fruit trees are normally planted in a piece of
land. In the second case the same sentence could become "the family owned a piece of land planted with fruit trees" or "as an orchard", thus eliminating the kinds of fruit trees, because it is common knowledge that both "fruit trees" and "orchards" comprise apple trees, pear trees, etc. And by combining the two procedures the sentence would, finally, be transformed into "the family owned an orchard".

In these operations, as we have seen, a certain part is played by the previous knowledge, the general culture of the person who summarises as well as of the person who uses the summary; but only in the case of implication through operations that are constitutive of both things, the implicant can call forth the implied thing without requiring any cultural education on the part of the reader; if the things merely accompany each other and this accompanying each other has not previously been examined and fixed into a certain pattern, this would be no longer possible. Also the "is known" and the "common knowledge" referred to above will have to be considered in relation to the type and the breadth of knowledge of the persons for whose use the particular summary is destined.

We have also referred to "actual operating", but so far this operating will be incorporated only in the observing and describing model, and even there, for various reasons, only in a very limited way. In mechanical summarising as in the case of mechanical translation this actual operating will be replaced as far as possible by a network of mutually connected notions, a network from which it will be ascertainable which things are in a certain relation and which relations have been set up between certain things. Both the projects on which we are working involve such a "Notional Sphere" and although it is at present still in a stage of development and expansion, the provisional draft we have been using so far is sufficient to show how one passes from one notion to another. (cf. page 19)
Since the correlational net corresponding to the input text will in any case be transformed in the summary it is possible also to choose the particular form that one wishes the summary to take: from a simple list of the notions occurring in the text to a series of sentences which could all be of a particular form (for instance limited to subject, verb and direct object) or of a limited variety of forms. The choice of an output form of this last kind would lead to expressions that would constitute a type of artificial language particularly suitable for purposes of documentation.

Our reason for taking part in the discussion on cooperation concerns the prospect of a closer cooperation between French and Italian scholars of mechanical translation and summarising and of the mechanisation of linguistic activities in general.

Cooperation of the purely personal kind that is usual in the international sphere of intellectual activity, that is to say cooperation among people who share an intellectual interest, exists already. Our group works in close collaboration with the GRISA team of EURATOM and thus also with the French scientists who belong to it.

National cooperation in this field, however, does not yet exist everywhere - at least not in the sense that the Government takes any definite official action in favour of the research in question. While the French Government has made a start by constituting the CETA (Centre d'Etudes
pour la Traduction Automatique), the Italian Government has so far not taken a similar decision. Our group which, at present, is the only one in Italy working on these subjects, owes its means of support exclusively to the United States Government and to EURATOM.

It is certain that the present meeting of French and Italian scholars will stimulate and reinforce the personal collaboration between them; and, given the presence of representatives of the two Governments, it would seem possible also that this meeting might prompt the Italian Government to make an official gesture comparable with that already made by the French.
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organ
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complementary object
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aspect (esp. phenomenal aspect)
activity or behaviour
material of activity
result of activity
instrument of activity
constitutive object
result
instrument
modality
ambience
habitual place
time
product
instrument
ambience
habitual place
time
agens
secondary effect (of activity)
function
result of function
finality of activity-instrument
material
result of activity-instrument
place of subject-activity
material
object
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