Colloque sur la coopération en matière de
Documentation et d'Information Scientifiques et Techniques

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Milan, 30 novembre - 3 décembre 1960
Sous le patronage de la Fédération des Associations
scientifiques et techniques de Milan

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Thought as the Basis of Mechanical
Translation and Summarising

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Thought as the Basis of Mechanical Translation and Summarising

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) trans-
lation 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.

A

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 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 character-
istic 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.

B

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

sat 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 preposition "of", which
designates nothing but the dual presentation of some-
thing 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.

C

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 meed 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 repre-
sentations 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 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 the 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·
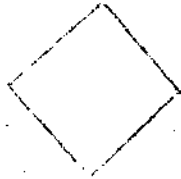
first as a parallelogram, then as a rhomb, and then as a square.   Or, to give another example, if we consider the following design

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).

E

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 act-
ivity 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 mqethod,
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 cultur-
al 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 con-
sidered in relation to the type and the breadth of knowledge
of the persons for whose use the particular summary is dest-
ined.

We have also referred to "actual operating", but
so far this operating will be incorporated only in the ob-
serving and describing model, and even there, for various
reasons, only in a very limited way. In mechanical summaris-
ing 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 realtions 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. page19).

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 sen-
tences 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.

G

Our reason for taking part in the discussion on
cooperation concerns the prospect of a closer cooperation
between French and Italian scholars of mechanical trans-
lation 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.

Preliminary List of Relations
Constituting the "NOTIONAL SPHERE"

1st Term	2nd Term
Element	collection
specimen	class
species	genus
part	whole
container	content
support	thing supported
thing pulling	thing pulled
thing looking after	thing being looked after
thing directing	thing being directed
component	composite
ornament	thing ornamented
thing provenient from	provenience
charcteristic	thing characterised
thing preceding	thing preceded
object	accessory
contiguity	
opposition	
ascending relationship	descending relationship

(third term: collateral relationship)

things worn or carried	things wearing or carrying them
objects	covers
means of protection	things from which they protect
historical appurtenance	
thing generated	generator
thing generated	ambience of generation
first stage	second stage of genetic development
activity and behaviour	accessory
object	object's physical state
material	form
constituent	thing constituted

object
economic relation
semantic relation
subject
subject
subject
subject
activity
activity
activity
activity
activity
activity
activity
material
object
object
object
object
activity
subject
organ
organ
instrument
object
instrument complementary of
    activity-instrument
instrument
complementary object
subject
activity
subject

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

S E L E C T E D   B I B L I O G R A P H Y

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