

## MACHINE TRANSLATION AND ABSTRACT TERMINOLOGY

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If I were responsible for the development of a system for automatic translation from one natural language into another, I should know without consulting anyone what parts I wanted the system to have and how I wanted them to be connected. Free of the responsibility, I am also free of any obligation to say what those parts and connections would be. Professor Lehmann has held such responsibility and made such decisions; I do not here propose to offer him any suggestions.

However, the characteristics of language that the design of the system must take into account constitute a different problem. Each of us has turned to the whole field of linguistics, past and present, with the hope of answering the question, "What is language that a machine might translate it?" None of us has found an answer that entirely satisfied him. With the purpose of improving a little on the existing situation, I begin by noting a few characteristics of language that are familiar to every linguist. Noting that one of them has paid less than its due in attention, I explore its significance for linguistics, thus familiarizing the reader with possibly new and at first sight strange topics. That prelude leads naturally into the main theme: What the unrespected characteristic of

language requires of the translator, and how a machine might satisfy the requirements.

#### THE FOURFOLD FACULTY OF LANGUAGE

The design features that Hockett (1960) has enumerated number more than a dozen. The functions of language that Jacobson (1960) expounded are exactly six. Being more modest, I (1974) am prepared to stop at four. The rest can be accounted for in one of two ways. Some can be derived from the basic four. Some are true of human speech but only accidentally so; without them, we could still recognize an extraterrestrial communication system as language. Any characteristic of language that is not accounted for by these two rules must be added to my initial four.

Duality of patterning is first. Phonologically, a language is an inventory of units and a set of principles of arrangement. Grammatically, a language is also an inventory of units and a set of principles of arrangement, but the two inventories have no common elements and the two lists of rules of arrangement have in common at most the appearance of units from one inventory as conditioning elements in a rule of the other sort. A plausible explanation for duality of patterning is that the two systems, layers, levels, strata, or components are in different parts of the brain (Whitaker 1970). Is it not then mere happenstance that human speech exhibits duality of patterning? Would we not recognize an alien system as language if it were without duality? Speculation about this question is wild, not plausible, but my guess is that no system, without duality can exist in a biological substrate at a degree of complexity sufficient to carry advanced culture. In other words, duality is a precondition of language in the true sense.

Semanticality is the second characteristic of language that I count as elementary or primitive and also essential. We perceive and act upon the world; and we conceive and speak of the world as we see it and act upon it. The highest level of coordination of perception and action links vision and proprioception to create space. Language links hearing, only

incidental in the perception-action system, with articulation. The organs of articulation are not extensible, hence can contribute little or nothing to the appreciation of space. The link between language and perception-action is therefore a highest linkage between two systems; such a linkage is, I think, the biological characterization of semanticity. Association cortex serves the organization of perception-action space and, elsewhere, the language system as such. Secondary association cortex looks like the mediator between the two and the site of semanticity.

Syntacticality is third. We perceive the world as composed of things bearing qualities and acting on one another; qualities or properties apply to entities and to actions, and entities participate in actions. Language must express these applications and these participations; to do so requires means of interconnection among units. The patterns of arrangement of grammatical units--morphemes, we can say--serve this function. The biological substrate of syntax is unknown, at least to me; to identify it and describe its operation seems urgent business.

Metalinguality is the fourth characteristic of language that I count as essential; it is the one that has been neglected. The elementary unit of language can be identified with simple or composite units of perception and action. Every human language also contains nonelementary units that cannot be identified in the same way; their presence is well known, but their inexplicability has aroused little concern. Such English words as *sin*, *Sunday*, *pneumonia*, *quark*, *marriage*, *obstreperousness*, *syndicate*, *conspiracy*, *profit*, and *morpheme* are related to perception and action only in exceedingly complex ways. If it were not for the human ability to take patterns, including patterns composed of linguistic units and relations, as units themselves, these words could not exist. Humans do have such an ability; metalinguality is the name I give to the characteristic of language and the ability on which it is founded.

I expect to be accused of two errors. One is to admit duality of patterning only between phonology and morphology. My weak defense is to

admit ignorance. Is there cognition, conceptual organization of thought, outside of language? Is there not semology as well as morphology within language? I am inclined to believe in cognition, with units and patterns of arrangement all its own; and I am more than half inclined to believe in an independent semology. Each pair of levels with its own units and arrangements, lying adjacent in the system, forces upon us something akin to duality of patterning. Since the neuroanatomical basis of duality between phonology and morphology is apparent enough for at least plausible speculation, and since the basis of further dualities is not so apparent, I am reluctant to speculate very definitely about the others.

The second expectable charge is that the metalingual capacity is not of its own kind, but derivable from the joint occurrence of the others. One version would be that metalinguality is only syntacticality in lexical disguise. Thus, the object of the verb *know* is sometimes a that-clause: *you know that butterflies are free*. The object clause is organized syntactically as object of the verb. This situation is comparable to the syntactic formulation of a definition for *conspiracy*, let us say, and the linkage of the word and its definition is comparable to the linkage of the object clause into the matrix sentence.

To the charge in this version, my defense is that syntax has been shown to contain metalinguality as a proper part, but the methods of syntax have not been proved homogeneous. We have all learned by now, from Fillmore (1968), that the subjects of

The door opened

The key opened the door.

The janitor opened the door with a key.

play different roles in the event. Each plays a role, however, and we can decide whether one of the sentences is being used appropriately by perceptual devices. We employ perceptual schemata to check for the presence in the surrounding situation of a door, a key, or a person. We employ perceptual schemata, perceptual-relational schemata, or something of the

kind, to check for the role the entity plays in the event. If the perceptual verification comes out right, we are satisfied.

It is not easy to imagine a perceptual schema for *know*, but I grant one for the sake of argument. It is not easy to imagine a perceptual schema for *Butterflies are free*, but I grant one for the sake of argument. It is far from easy to imagine a perceptual-relational schema for the participation of an abstract entity in an informational event, but I grant even that for the sake of argument. What I cannot grant is the link between the perceptual schema, however complex, and the abstract entity. Said another way, if *that* is analyzed as an abstract pronominal, defined by the following clause, serving the object role relative to *know*, then I cannot grant that perception is responsible for the interpretation of the link between *that* and *Butterflies are free*. This one link must be characterized within the analysis of language, whether the items granted for the sake of argument be treated within or without. And I claim that it is the same kind of link as the one that attaches *pneumonia* to the linguistic pattern that defines it.

Another approach may clarify my views. To speak of *semantics* strikes me as obscure. The human language user has conceptual-linguistic capacities and perceptual-motoric capacities. Outside is a world to which he responds. We can locate a regularity in the world, in the perceptual system, or in linguistic system. I think that the link between an abstract term and its definition cannot be driven out into the world, or even into the perceptual-motoric domain. To try too hard to decide whether the capa-

city that gives us abstract terms and clauses embedded in sentences under informational verbs lies in the conceptual or the linguistic system would be an error, since at present we are in no position to sharpen that boundary. The conceptual-linguistic distinction may even be a false dichotomy.

Finally, I wish to display three contrasts in the hope of clarifying my point for those to whom it is still murky. The pairs are *universal-particular*, *general-special*, and *abstract-concrete*.

A universal term is a kind of variable for which substitution of a particular is admissible. Thus *boy* is a universal, and *Tom, Dick, or Harry* is a particular.

A general terra is a variable over a relatively unrestricted domain; a special terra is a variable over a relatively restricted domain. Thus *human being* is more general and *boy* is more special. From the most general to the most particular is often a scale of several steps.

An abstract term is one for which only verbal definition is possible; it is the name of a pattern in which the elements are linguistic-conceptual elements and the relations are linguistic-conceptual relations. A concrete term is one for which direct perceptual or motoric definition is possible.

I am unable to see how the capacity for abstract thought can be derived from the joint presence of duality of patterning, semanticality, and syntacticality, unless one of them be understood in such a way as to include metalinguality specifically. Hence I take it that language is a fourfold faculty in the human species, which we correctly refuse to recognize elsewhere unless all four characteristics are demonstrated.

#### SEMANTIC TRANSLATION

In the two and a half decades since translation was first suggested on the basis of a cryptographic view of language (Weaver 1955), or if you prefer in the one and a half decades since MT banged its head against the stone wall of semantics (Don R. Swanson, at a 1960 conference in Los Angeles), a blow felt by some to have caused a concussion adequate to explain its general lethargy ever since (Professor Lehmann being among the few to remain alert), linguistics has progressed, revealing at each step solutions to old problems and the lack of solutions to previously undiscovered difficulties.

The cryptographic solution thought of each language as a code concealing a message; and so it may be, but the code of natural language is of a depth, subtlety, and orderliness unknown to traditional cryptography.

The syntactic solution to the machine-translation problem thought of each language as providing a unique means of expressing conceptual structure.

The semantic solution thought of each language as having a unique conceptual structure that would have to be decoded or translated into a canonical form and thence into a target language.

Translation is not a problem at all, and has no solution. Translation is a task. Linguistic theory can help in the formulation of the task, but to get the best translation by machine within limitations of understanding, of equipment, of setup costs, and of operating costs is design work for engineers. To say what characterizes good translations is the business of human engineering, not of linguistics. All I hope to do here is apply the undervalued theory of abstract definition-metalinguality--to the formulation of the task of translation. Engineers in computational linguistics can consider how if at all their designs--algorithms--can incorporate elements of the new formulation. Human engineers can test by experiment whether the altered designs produce better translations.

The simplest point is that when an abstract term has to be translated an equivalent must be found. The choice of target-language equivalents for source-language terms is fraught with difficulties; no term exists, or a comparable but crucially different term exists, or several crucially different terms exist among which a selection must be made.

I can give you some examples to make the nature of the problem more gripping. In many cultures, the basis for capitalism does not exist, and no term for the concept can be found. Possession and exchange are understood differently; transfer of possession may not occur, or if at all by schemes in which exchange does not figure. It is often said that Americans and Russians have crucially different conceptions of democracy. In American tax law, corporate reorganization is defined as subject to tax or free from tax in accordance with such involved analyses of the procedure followed that the statutes and prior decisions together leave room for doubt in certain cases (This from Thorne McCarty.)

If the source-language text contains *capitalism*, the translator can transliterate, or create a polylexemic term ad hoc; in either case, the insertion of a footnote on first occurrence can help the reader. The system designer will choose one of these methods, with or without footnotes, according to cost allowances and human-engineering studies.

If the source-language text contains *democracy*, and is Russian or English, the translator into the other language can use the ordinary translation, with or without a footnote. If the target language is English, an appropriate translation may be *(Russian) democracy*,

What to do with *tax-exempt reorganization*, or any related expression, is more difficult. The target language may offer a number of terms for a pattern of legal manipulation as prescribed in the laws of one or another country in which the target language is spoken. The trained reader of English learns much more than that no tax was paid when he sees the expression *tax-free*; he learns, approximately, by what methods the reorganization was carried out. The author expected the reader to learn that much, and if the translation conveys less, it is incomplete. Another version arises if the source-language describes the reorganization with a term that fits into the legal description of a tax-free merger, so that the reader should infer that no tax is paid.

To pretend that the translation of *tax-free merger* is adequate if it contains translations of *merger*, *tax*, and *free*, so chosen that *free* is understood to mean 'without liability for, unencumbered by, exempt from', and so connected syntactically that the reader knows the merger to be exempt from taxation, is easy enough; we have all mounted such pretenses and lived in their shelter. Theoretical and descriptive linguists thus lose the challenge of abstract definition and metalinguality. Linguist engineers, MT system designers, thus lose quality points for their product. Consumers lose a part of the understanding they pay for.

To give up the pretense is difficult. If we do that we must begin collecting abstract definitions, specifying the modes by which they are constructed, and developing techniques for translation when source and



target language have sets of terms with related, overlapping terms with intricate specifications for choice among them and perhaps no exact matches. The difficult route may nevertheless lead to rewards that the other way does not approach.

What I know about modes of abstract definition is little more than this: that analysis by distinctive features is an oversimplification to the point of worthlessness, and that an abstract definition can contain any relation that might be found in a text of the same language. Two terms can therefore differ by the attribution of one or another quality to some participant in one of several events that are causally linked in the definition! One person is called *charitable*, the other *patronising*, because the one acts without hope of reward and the other acts in order to obtain social deference. In some languages matching terms exist, but there are no doubt far more languages in which the translator, to be exact, must choose a less specific term and add a word of explanation. And how to translate from such a language into English? 'Look in the text for some indication whether the actor expects a reward'?

That, I remind you, is the simplest point I have to make. All the rest seem so difficult that I can only take them up in arbitrary order and in the most general terms.

An author can select one word in preference to another because it enters the abstract definition of a word that he wants to suggest but not to use. A physician speaking to a patient can hint at cancer without naming it. A linguist writing tendentiously can suppress the theoretical terminology of his opponent. A novelist characterizing one of his dramatic personae can recite his generous contributions and speak either of the rewards that follow or of the person's avoidance of the channels that lead to reward, permitting the reader to recognize absence or presence of charity. In these cases, more or less likely to appear in the input for machine translation, the choice of a target-language equivalent should be made so as to call to the target-language reader's mind the definition, and so the term, that the source-language reader would think of. I note,

without taking over the designer's job, that such selection can be made only with the help of storage in which definitions can be addressed both forward and in reverse. From *charity* to its definition containing *regard* is forward; from *reward* to its use in a definition to the defined *charity* is reverse.

The coherence of a text depends on the consistency of the entities, human or other, that appear in it from beginning to end; on the spatio-temporal, causal, or purposive linkage of the events recited; on figures of comparison and contrast that attach to the main thread all the little things that of their own nature do not belong; and on thematic coherence. The theme of a text is named by an abstract term and is expounded by the match of the text as a whole to the abstract definition of the term.

To maintain consistency of entity list, plot linkage, and figurative linkage through a text is automatic for the translator, whether human or machine. To maintain thematic consistency is, if I make no mistake, carried out unconsciously or not at all. It is time to do better.

The themes of science are called paradigms (Kuhn 1962). The writer and the reader he expects to confront have learned certain anecdotes about particles and forces, if they are physicists; about levels, units, and rules, if they are linguists; about subjects, experimenters, and apparatus, if they are psychologists; and so on. The name of an anecdote is something like *particle accelerator* (physics), *contrast* (linguistics), *stimulus-response* (psychology), etc. In their anecdotes, they are accustomed to certain subplots and certain terminology. The translator of a paper in psychology does well to know that it employs the stimulus-response paradigm before beginning to translate, since that fact alone may determine many terminological choices. The same is true of every branch of science.

The themes of fiction are generally concepts of folk psychology, or sociology, or of theology. They are defined by paradigms of common sense, or of religion. A story told without characters or plot is nonsense; but so is a story told with both, but lacking a moral. The daring author chooses a familiar paradigm and ends with an antimoral, but only a few

despise order to the point of omitting moral and antimoral together.

Scientific texts are reputedly easy to translate. What gives this reputation is, I think, its status as an independent culture, transmitted formally and uniformly everywhere. Its paradigms are known to its practitioners regardless of native language. The translation made without reference to thematic structure has a good chance of being understood for that reason. Some paradigms appear in all sciences, but most are the property of a science or group of sciences, unknown elsewhere. Hence many terms are used without conflict for different concepts (i.e., with different abstract definitions) in different fields. To translate them, it is necessary to know what field the text comes from; but that is not literally sufficient, since the term belongs to a paradigm--a theme--and not to a field of science specially. The translator needs to be able to detect paradigms as they appear in the source-language text.

Outside the hardest core of science, the translator has a further reason for knowing what paradigm he is translating; it may be unfamiliar to the intended reader of the translation. Once more, footnotes may be needed. The translation of a novel may be successful only if a preface or endnote is added, describing the theme for the reader in whose culture it is unknown. To understand a text is in part to recognize the manner in which it fits the definition of a thematic term; if the reader does not have the theme in his repertoire, he cannot recognize it and so cannot feel that he understands.

Might a machine someday extract a theme from a text? I think so. The task seems to resemble the now familiar task of transformational parsing, or of theorem proving. Before seriously contemplating the task of theme extraction, we might work on the identification of character descriptions, plots, and figures of contrast and comparison. Portions of a text can be organized by minor themes. The whole of a text may be organized as the exemplification of a major theme, the exposition of a character, or the resolution of a plot. Very likely the best texts show these three modes of organization equally and completely.

The technique--I violate my restriction slightly by mentioning it-- is pattern recognition. Transformational grammar and theorem proving maintain elaborate data structures in which they repeatedly search for patterns. An abstract definition, even of a theme, is a pattern in roughly the same sense. The designer's problem is to devise a suitable data structure for texts in work, and economical procedures for seeking patterns of plot, of character development, of comparison or contrast, and of theme. The number of such patterns in a culture is large, but may not be excessive for the computers of the next generation. Economy may lie in systems that seek all patterns simultaneously, as the brain may do, or in systems that cleverly avoid looking for patterns that are not there [Hays 1973].

#### REMARKS

My prescription for translators is, understand the input text, and say what it says in the output language. The four parts of the human faculty of language are all required. Duality of patterning forces the translator to use a dictionary; if duality of patterning is repeated, several dictionaries are needed. Syntacticality forces the translator to parse the input, and to go through a corresponding output stage, in order to verify the conceptual linkages intended by the author. Semanticity guides the translator, who strives to match input and output according to semantic values. Metalinguality forces the translator to deal vigorously with abstract terms and to look for the overall thematic structure of the input. Nothing forces the translator to build these four parts of his system separately, or to operate them sequentially. He can make his system guess the theme of the text and drive the syntactic portion with thematic predictions. He can generate syntactic structures and match them against input and thematic possibilities simultaneously. Or he can do dictionary lookup, syntax, semantics, and abstract patterns with independent components in that order--but only if he thus obtains a better design.

The faculty of language is enormously powerful; it is linked with, and evidently supplies the means for, culture, art, and science. The theories of language generally cited, capturing phonological and grammatical patterns, with semantic sources of the complexity of the predicate calculus, give no better explication of culture and science than the predicate calculus gives, and it has no means by which to extend its repertoire with symbols standing for patterns of its own symbols. The first step toward a theory of abstraction is the recognition that, however difficult it be, it is needed.

Machine translation, as I have remarked before, is interesting above all for the appetite with which it absorbs everything linguistics can provide. Professor Lehmann deserves credit for keeping this hungry monster in a zoo when other relegated it to a museum. We can estimate how far along we have gotten toward knowing how we understand language by inspecting the output of a contemporary and carefully engineered translation system. I submit the notion of abstract definition in the hope that it will eventually contribute to better translation and thereby prove itself a contribution to linguistics.<sup>1</sup>

## NOTES

The dissertations of Mary White and Bryan Phillips have been accepted by SUNY Buffalo, and some papers by William Benzion have been accepted for publication, one in *Modern Language Notes*. Gerald Holton has published a book on themata in science. Marvin Minsky and Roger Schank have published on 'frames' and 'scripts'. Linguistics seems, not yet to have arrived at a theory of abstract definition.

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