ABSTRACT

Approaches to MT have been heavily influenced by changing trends in the philosophy of language and mind. Because of the artificial hiatus which followed the publication of the ALPAC Report, MT research in the 1970s and early 1980s has had to catch up with major developments that have occurred in linguistic and philosophical thinking; currently, MT seems to be uncritically loyal to a paradigm of thought about language which is rapidly losing most of its adherents in departments of linguistics and philosophy. I argue, both in theoretical terms and by reference to empirical research on a particular translation problem, that the Popperian "fallible rationalist" view of mental processes which is winning acceptance as a more sophisticated alternative to Chomskyan "deterministic rationalism" should lead MT researchers to redefine their goals and to adopt certain currently-neglected techniques in trying to achieve those goals.

1. Since the Second World War, three rival views of the nature of the human mind have competed for the allegiance of philosophically-minded people. Each of these views has implications for our understanding of language.

The 1950s and early 1960s were dominated by a behaviourist approach tracing its ancestry to John Locke and represented recently e.g. by Leonard Bloomfield and B.F. Skinner. On this view, "mind" is merely a name for a set of associations that have been established during a person's life between external stimuli and behavioural responses. The meaning of a sentence is to be understood not as the effect it has on an unobservable internal model of reality but as the behaviour it evokes in the hearer.

During the 1960s this view lost ground to the rationalist ideas of Noam Chomsky, working in an intellectual tradition founded by Plato and reinaugurated in modern times by Rene Descartes. On this view, stimuli and responses are linked only indirectly, via an immensely complex cognitive mechanism having its own fixed principles of operation which are independent of experience. A given behaviour is a response to an internal mental event which is determined as the resultant of the initial state of the mental apparatus together with the entire history of inputs to it. The meaning of a sentence must be explained in terms of the unseen responses it evokes in the cognitive apparatus, which might take the form of successive modifications of an internal model of reality that could be described as "inferencing".

Chomskyan rationalism is undoubtedly more satisfactory as an account of human cognition than Skinnerian behaviourism. By the late 1970s, however, the mechanical determinism that is part of Chomsky's view of mind appeared increasingly unrealistic to many writers. There is little empirical support, for instance, for the Chomskyan assumptions that the child's acquisition of his first language, or the adult's comprehension of a given utterance, are processes that reach well-defined terminations after a given period of mental processing -- language seems typically to work in a more "open-ended" fashion than that. Within linguistics, as documented e.g. by Moore & Carling (1982), the Chomskyan paradigm is by now widely rejected.

The view which is winning widespread acceptance as preserving the merits of rationalism while avoiding its inadequacies is Karl Popper's fallibilist version of the doctrine. On this view, the mind responds to experiential inputs not by a deterministic algorithm that reaches a halt state, but by creatively formulating fallible conjectures which experience is used to test. Typically the conjectures formulated are radically novel, in the sense that they could not be predicted even on the basis of ideally complete knowledge of the person's prior state. This version of rationalism is incompatible with the materialist doctrine that the mind is nothing but an arrangement of matter and wholly governed by the laws of physics; but, historically, materialism has not commonly been regarded as an axiom requiring no argument to support it (although it may be that the ethos of Artificial Intelligence makes practitioners of this discipline more than averagely favourable towards materialism).

As a matter of logic, fallible conjectures in any domain can be eliminated by adverse experience but can never be decisively confirmed. Our reaction to linguistic experience, consequently, is for a Popperian both non-deterministic and open-ended. There is no reason to expect a person at any age to cease to improve his knowledge of his mother-tongue, or to expect different members of a speech-community to formulate identical internalized grammars; and understanding an individual utterance is a process which a person can...
execute to any desired degree of thoroughness -- we stop trying to improve our understanding of a particular sample of language not because we reach a natural stopping-place but because we judge that the returns from further effort are likely to be less than the resources invested.

For a Chomskyan linguist, divergences between individuals in their linguistic behaviour are to be explained either in terms of mixture of "dialects" or in terms of failure of practical "performance" fully to match the abstract "competence" possessed by the mature speaker. For the Popperian such divergences require no explanation; we do not possess algorithms which would lead to correct results if they were executed thoroughly. Indeed, since languages have no reality independent of their speakers, the idea that there exists a "correct" solution to the problem of acquiring a language or of understanding an individual sentence ceases to apply except as an untheoretical approximation. The superiority of the Popperian to the Chomskyan paradigm as a framework for interpreting the facts of linguistic behaviour is argued e.g. in my Making Sense (1980), Popperian Linguistics (in press).

2. There is a major difference in style between the MT of the 1950s and 1960s, and the projects of the last decade. This reflects the difference between behaviourist and deterministic-rationalist paradigms. Speaking very broadly, early MT research envisaged the problem of translation as that of establishing equivalences between observable, surface features of languages: vocabulary items, taxemes of order, and the like. Recent MT research has taken it as axiomatic that successful MT must incorporate a large AI component. Human translation, it is now realized, involves the understanding of source texts rather than mere transliteration from one set of linguistic conventions to another: we make heavy use of inferencing in order to resolve textual ambiguities. MT systems must therefore simulate these inferencing processes in order to produce human-like output. Furthermore, the Chomskyan paradigm incorporates axioms about the kinds of operation characteristic of human linguistic processing, and MT research inherits these. In particular, Chomsky and his followers have been hostile to the idea that any interesting linguistic rules or processes might be probabilistic or statistical in nature (e.g. Chomsky 1957: 15-17, and of. the controversy about Labovian "variable rules"), the assumption that human language-processing is invariably an all-or-none phenomenon might well be questioned even by someone who subscribed to the other tenets of the Chomskyan paradigm (e.g. Suppes 1970), but it is consistent with the heavily deterministic flavour of that paradigm. Correspondingly, recent MT projects known to me seem to make no use of probabilistic processes occurring within individual humans are themselves intrinsically probabilistic. To draw an analogy: life-insurance companies do not condemn the actuarial profession as a bunch of cop-outs because they do not attempt to predict the precise date of death of individual policyholders. MT research ought to exploit any techniques that offer the possibility of better approximations to acceptable translation, whether or not it seems likely that human translation exploits such techniques; and it is likely that useful methods will often be probabilistic.

3. What are the implications for MT, and for AI in general, of a shift from a deterministic to a fallibilist version of rationalism? (On the general issue see e.g. the exchange between Aravind Joshi and me in Smith 1982.) They can be summed up as follows.

First, there is no such thing as an ideal speaker's competence which, if simulated mechanically, would constitute perfect MT. In the case of "literary" texts it is generally recognised that different human translators may produce markedly different translations none of which can be considered more "correct" than the others; from the Popperian viewpoint literary texts do not differ qualitatively from other genres. (Referring to the translation requirements of the Secretariat of the Council of the European Communities, P.J. Arthern (1979: 81) has said that "the only quality we can accept is 100% fidelity to the meaning of the original". From the fallibilist point of view that is like saying "the only kind of motors we are willing to use are perpetual-motion machines".)

Second, there is no possibility of designing an artificial system which simulates the actions of an unpredictably creative mind, since any machine is a material object governed by physical law. Thus it will not, for instance, be possible to design an artificial system which regularly uses inferencing to resolve the meaning of given texts in the same way as a human reader of the texts. There is no principled barrier, of course, to an artificial system which applies logical transformations to derive conclusions from given premises. But an artificial system must be restricted to some fixed, perhaps very large, database of premises ("world knowledge"). It is central to the Popperian view of mind that human inferencing is not limited to a fixed set of premises but involves the frequent invention of new hypotheses which are not related in any logical way to the previous contents of mind. An MT system cannot aspire to perfect human performance. (But then, neither can a human.)

Third: a situation in which the behaviour of any individual is only approximately similar to that of other individuals and is not in detail predictable even in principle is just the kind of situation in which probabilistic techniques are valuable, irrespective of whether or not the processes occurring within individual humans are themselves intrinsically probabilistic. To draw an analogy: life-insurance companies do not condemn the actuarial profession as a bunch of cop-outs because they do not attempt to predict the precise date of death of individual policyholders. MT research ought to exploit any techniques that offer the possibility of better approximations to acceptable translation, whether or not it seems likely that human translation exploits such techniques; and it is likely that useful methods will often be probabilistic.

Fourth: MT researchers will ultimately need to appreciate that there is no natural end to the process of improving the quality of translation (though it may be premature to raise this issue
at a stage when the best mechanical translation is still quite bad). Human translation always involves a (usually tacit) cost-benefit analysis: it is never a question of "How much work is needed to translate this text 'properly'" but of "Will a given increment of effort be profitable in terms of achieved improvement in translation?" Likewise, the question confronting MT is not "Is MT possible?" but "What are the disbenefits of translating this or that category of texts at this or that level of inexactness, and how do the costs of reducing the incidence of a given type of error compare with the gains to the consumers?"

4. The value of probabilistic techniques is sufficiently exemplified by the spectacular success of the Lancaster-Oslo-Bergen Tagging System (see e.g. Leech et al. 1983). The LOB Tagging System, operational since 1981, assigns grammatical tags drawn from a highly-differentiated (134-member) tag-set to the words of "real-life" English text. The system "knows" virtually nothing of the syntax of English in terms of the kind of grammar-rules believed by linguists to make up the speaker's competence; it uses only facts about the local transition-probabilities between form-classes, together with the relatively meagre clues provided by English morphology. By late 1982 the output of the system fell short of complete success (defined as tagging identical to that done independently by a human linguist) by only 3.4%. Various methods are being used to reduce this failure-rate further, but the nature of the techniques used ensures that the ideal of 100% success will be approached only asymptotically. However, the point is that no other extant automatic tagging-system known to me approaches the current success-level of the LOB system. I predict that any system which eschews probabilistic methods will perform at a significantly lower level.

5. In the remainder of this paper I illustrate the argument that human language-comprehension involves inferencing from unpredictable hypotheses, using research of my own on the problem of "referring" pronouns.

My research was done in reaction to an article by Jerry Hobbs (1976). Hobbs provides an unusually clear example of the Chomskyan paradigm of AI research, since he makes his methodological axioms relatively explicit. He begins by defining a complex and subtle algorithm for referring pronouns which depends exclusively on the grammatical structure of the sentences in which they occur. The algorithm is very successful: tested on a sample of texts, it is 88.3% accurate (a figure which rises slightly, to 91.7%, when the algorithm is expanded to use the simple kind of semantic information represented by Katz/Fodor "selection restrictions"). Nevertheless, Hobbs argues that this approach to the problem of pronoun resolution must be abandoned in favour of a "semantic algorithm", meaning one which depends on inferencing from a data-base of world knowledge rather than on syntactic structure. He gives several reasons; the important reasons are that the syntactic approach can never attain 100% success, and that it does not correspond to the method by which humans resolve pronouns.

However, unlike Hobbs's syntactic algorithm, his semantic algorithm is purely programmatic. The implication that it will be able to achieve 100% success -- or even that it will be able to match the success-level of the existing syntactic algorithm -- rests purely on faith, though this faith is quite understandable given the axioms of deterministic rationalism.

I investigated these issues by examining a set of examples of the pronoun it drawn from the LOB Corpus (a standard million-word computer-readable corpus of modern written British English -- see Johansson 1978). The pronoun it is specially interesting in connexion with MT because of the problems of translation into gender-languages; my examples were extracted from the texts in Category H of the LOB Corpus, which includes governmental and similar documents and thus matches the genres which current large-scale MT projects such as EUROTRA aim to translate. I began with 338 instances of it; after eliminating non-referential cases I was left with 156 instances which I examined intensively.

I asked the following questions:

(1) In what proportion of cases do I as an educated native speaker feel confident about the intended reference?

(2) Where do I feel confident and Hobbs's syntactic algorithm gives a result which I believe to be wrong, what kind of reasoning enabled me to reach my solution?

(3) Where Hobbs's algorithm gives what I believe to be the correct result, is it plausible that a semantic algorithm would give the same result?

(4) Could the performance of Hobbs's syntactic algorithm be improved, as an alternative to replacing it by a semantic algorithm?

It emerged that:

(1) In about 10% of all cases, human resolution was impossible: on careful consideration of the alternatives I concluded that I did not know the intended reference (even though, on a first relatively cursory reading, most of these cases had not struck me as ambiguous). An example is:

The lower platen, which supports the leather, is raised hydraulically to bring it into contact with the rollers on the upper platen ... (H6.148)

Does it refer to the lower platen or to the leather (la piastra, il cuoio)? I really don't know. In at least one instance (not this one) I reached different confident conclusions about the same case on different occasions (and this suggests that there are likely to be other cases which I have confidently resolved in ways other than the writer intended). The implication is
that a system which performs at a level of success much above 90% on the task of resolving referent-
ial it would be outperforming a human, which is 
contradictory: language means what humans take it to mean.

(2) In a number of cases where I judged the syntac-
tic algorithm to give the wrong result, the 
premises on which my own decisions were based were propositions that were not pieces of factual 
general knowledge and which I was not aware of 
ever having consciously entertained before pro-
ducing them in the course of trying to interpret 
the text in question. It would therefore be 
quixotic to suggest that these propositions 
would occur in the data-base available to a future 
MT system. Consider, for instance:

Under the "permissive" powers, however, in 
the worst cases when the Ministry was right and 
the M.P. was right the local authority could still 
dig its heels in and say that whatever the Mini-
stry said it was not going to give a grant. (H16. 
24)

I feel sure that it refers to the local authority 
rather than the Ministry, chiefly because it seems to me much more plausible that a lower-level 
branch of government would refuse to heed requests 
for action from a higher-level branch than that it 
would accuse the higher-level branch of deceit. 
But this generalization about the sociology of 
government was new to me when I thought it up for 
the purpose of interpreting the example quoted 
(and I am not certain that it is in fact univers-
ally true).

(3) In a number of cases it was very difficult to 
believe that introduction of semantic consider-
atations into the syntactic algorithm would not 
worsen its performance. Here, an example is:

... and the Isle of Man. We do by these 
 Presents for Us, our Heirs and Successors instit-
ute and create a new Medal and We do hereby direct 
that it shall be governed by the following rules 
and ordinances ... (H24.16)

Hobbs's syntactic algorithm refers it to Medal, 
I believe rightly. Yet before reading the text 
I was under the impression that medals, like other 
small concrete inanimate objects, could not be 
governed; while territories like the Isle of Man 
can be, and indeed are. Syntax is more important 
than semantics in this case.

(4) There are several syntactic phenomena (e.g. 
parallelism of structure between successive 
clauses) which turned out to be relevant to pro-
noun resolution but which are ignored by Hobbs's 
algorithm. I have not undertaken the task of mod-
fying the syntactic algorithm in order to exploit 
these phenomena, but it seems likely that the 
already-good performance of the algorithm could be 
further improved.

It is also worth pointing out that accepting 
the legitimacy of probabilistic methods allows one 
to exploit many crude (and therefore cheaply-
exploited) semantic considerations, such as Katz/
Fodor selection restrictions, which have to be 
left out of a deterministic system because in 
practice they are sometimes violated. As we have 
seen, Hobbs suggested that only a small percentage 
improvement in the performance of his pure syntac-
tic algorithm could be achieved by adding semantic 
selection restrictions. Rules such as "the verb 'fear' must have an [-animate] subject" almost 
ever prove to be exceptionless in real-life usage: 
even genres of text that appear soberly literal 
contain many cases of figurative or extended usage. 
This is one reason why advocates of a "semantic" 
approach to artificial language-processing believe in 
using relatively elaborate methods involving 
complex inferential chains -- though they give us 
little reason to expect that these techniques too 
will not in practice be bedevilled by difficulties 
similar to those that occur with straightforward 
selection restrictions. However, while it may be 
that the subject of 'fear' is not always an anim-
ate noun, it may also be that this is true with 
much more than chance frequency. If so, an arti-
ficial language-processing system can and should 
use this as one factor to be balanced against 
others in resolving ambiguities in sentences con-
taining 'fear'.

6. To sum up: the deterministic-rationalist 
philosophical paradigm has encouraged MT research-
ers to attempt an impossible task. The fallible-
rationalist paradigm requires them to lower their 
sights, but may at the same time allow them to 
attain greater actual success.

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