Chapter 1

INTRODUCTION

I gave her one, they gave him two,
You gave us three or more;
They all returned from him to you,
Though they were mine before.
— *Lewis Carroll*[1]

1.1. Natural language understanding

This thesis addresses a problem central to the understanding of natural language by computer.[2] There are two main groups of reasons for wanting a computer to understand natural language: practical and theoretical.

In the set of practical reasons is useful human-machine communication. At present, computer programs, database queries and the like must be expressed in some artificial computer language, human use of which requires training and practice. If people were able to specify their instructions to computers in their own natural language, then they would be able to avail themselves of computer services without the need to learn special languages.

Presently, there are some prototypical systems which answer questions or write programs in response to commands expressed in a subset of English. Of these, few other than LSNLIS (Woods, Kaplan and Nash-Webber 1972) and ROBOT (Harris 1977, 1978) have been tested in the real world of potential users. Each system uses a slightly different subset of English, providing varying coverage and habitability;[3] however, none is without important gaps. For more discussion of this point, and a survey of some systems, see Petrick (1976).

Also of practical use would be a machine translation system which could translate documents from one natural language to another. Some such systems are already in everyday use (Hutchins 1978), but their performance still leaves much to be desired.

The theoretical reasons for studying NLU are to create, test and study models of language. Presently, major models of language such as

[1] From: *Alice's Adventures in Wonderland.* Chapter 12.

[2] "Natural language understanding" may be abbreviated "NLU".

[3] The HABITABILITY (Watt 1968) of a subset of English is the ease with which a user can conform

transformational grammars (Chomsky 1957, 1965) and generative semantics (Lakoff 1968, 1971; McCawley 1968; reviewed by Gelbart 1976) have in practice been synthetic rather than analytic; that is, they account for sentence structure by generating the sentence from a DEEP REPRESENTATION.[4] However, this is only one half of the communication process; the other is perceiving and understanding the sentence. So far there has been no equally significant model for this, the analytic component of language. Research into computer programs which understand can help fill this gap. Not only does such research lead in the direction of a model, but implementation as a computer program provides a means for testing and evaluating analytic theories and models; in a sense, the implementation IS the model (cf Winston 1977:258; Weizenbaum 1976:140-153).[5]

In this thesis, we shall be interested in the second reason as much as the first. Therefore, we will, as much as possible, be investigating the whole of a natural language, specifically English, rather than restricting ourselves to a habitable subset for human-machine communication. Further, we shall be considering connected discourse rather than isolated sentences. The motivation for this is that many of the interesting problems of language, such as cohesion and reference, do not occur in their full glorious complexity in a single sentence. (This is not to imply, however, that there are not still problems aplenty in single sentences.)

> *The term anaphora does not appear in many texts and monographs on linguistics, or it appears only in passing – an omission not at all surprising, given the fact that the concept of anaphora is of central importance to discourse structure.*
>
> – *William O Hendricks (1976:65)*

1.2. Reference and anaphora

The particular problem we shall be considering is that of anaphora and reference. Reference is a central concept in language, and is one that philosophers have studied and pondered for many years (for example, Russell (1905), Strawson (1950), Linsky (1963) and Donnellan (1966)). In recent years, linguists,

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to its restrictions.

[4]Theoretically, this statement is not correct. Chomsky (1957:48) emphasizes the neutrality in principle of transformational grammars with respect to synthesis or analysis of sentences. In practice, however, transformational grammars have not proved useful in automatic NLU; see section 3.2.5 and Woods (1970:596-597).

[5]I am aware that whether an implementation can constitute a theory is a controversial point, and I do not wish to pursue it here, as it has been discussed at much length in the oral presentations at (but, regrettably, not in the written proceedings of) the second conference on Theoretical Issues in Natural Language Processing, at the University of Illinois at Urbana-Champaign, July 1978. (For a summary of the views expressed at the conference on this matter, see Hirst (1978a).) It is necessary here only to assert the weaker view that an implementation, if not itself a theory, can aid understanding of a theory. Friedman, Moran and Warren's (1978) computer programs for Montague grammars exemplify this.

psychologists and artificial intelligence (AI) workers have seen its relevance to their fields, and have researched many aspects of it.

The problem essentially is that of how words are able to denote concepts, and in particular how a certain sequence of words can denote a unique concept. For example, if I meet you and say, apropos of nothing:

(1-1) The chinchilla ate my portrait of Richard Nixon last night. It devoured it so fast, I didn't even have a chance to save the frame.

you are somehow able to determine that by *Richard Nixon* I mean Richard Milhous Nixon, ex-President of the United States of America, and not Richard Chomsky Nixon, sanitation engineer of Momence, Illinois. You further understand which chinchilla, of all in the world, I mean by *the chinchilla,*[6] that *it devoured it* refers to the aforementioned chinchilla's aforementioned act of eating the aforementioned portrait, and that *the frame* is the frame of the aforementioned portrait.

Any language comprehender needs to make decisions all the time similar to those you made in reading the last paragraph. It needs to identify concepts when they are initially referenced and to identify subsequent references to them. Loosely speaking – we shall have a more formal definition in the next chapter – ANAPHORA is the phenomenon of subsequent reference.[7]

Because no coherent discourse is without both initial and subsequent reference, it is essential that any (computer) NLU system not limited to single sentence input be able to handle reference. (It is also advisable even in systems so limited, since intrasentential reference is very common.) That is the motivation for this thesis.

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[6]Note that it is not enough that *the chinchilla* identify the particular chinchilla uniquely to each of us. We must also both know that it identifies the same chinchilla to both of us. It is sometimes necessary that such mutual knowledge regress to infinity to ensure the felicity of such definite references; see Clark and Marshall (1978) for a demonstration of this, and a solution to the problems it raises.

[7]Do not confound this sense of the word *anaphora* with its use in rhetoric to mean the deliberate repetition of a word or phrase at the start of several successive verses or paragraphs, nor with its liturgiological meanings.