

GHOSTS IN THE MACHINE :  
AN AI TREATMENT OF MEDIEVAL HISTORY

Margaret King  
ISSCO, Universite de Geneve,  
Geneva, Switzerland

Monique Ornato, Gian Piero Zarri, Lucia Zarri-Baldi, Anne Zwiebel  
ERHF, Centre National de la Recherche Scientifique,  
Paris, France

Abstract

This paper gives a generalized overview of RESEDA, an interactive question answering system designed primarily for use by historians. Its data base consists of historical information, which attempts to describe the attitudes, political, religious and interpersonal, of the chief characters of the period. Question answering is done by search of the data base and by inference on the information therein. The difficulties of representing this type of data and of formulating inference rules dealing with human motivations and attitudes is also discussed.

Descriptive terms

Question answering, data base, representation, inference, biographical data, mediaeval history.

Introduction

The ghosts of the title are characters of frenchmediaeval history. The project described here (the RESEDA\* project) is an attempt to design a question answering system where the data base which is to provide the raw material for the answers consists of biographical data, culled from a variety of contemporary and modern sources, concerning the humanist literary movement in France. Questions to the system are input in a strict formalization. Answers, which appear in the same format, are found by interrogation of the data base or by inference making on the contents of the data base. The peculiar difficulties presented by the type of data dealt with and by the methods of inference needed are great enough to justify neglecting, or at least, postponing, the problem of natural language input.

Section 1 of this paper fills in the background by trying to explain some of the peculiarities of the data, Section 11 to show how these have been dealt with at the representation level by taking an example text and showing how it has been coded. Section 111 demonstrates some of the inference techniques used by following in detail the process of finding an answer to a question about a piece of text presented in Section 11, and the conclusion sketches further planes.

Section 1 : Problems presented by the data

The difficulties presented by the data break down into two main classes. First there are those which are a direct consequence of dealing with historical data. Secondly there are problems inherent in any attempt to deal with data which expres-

ses not only facts but beliefs, attitudes and complex relationships.

Let us first consider the problems of historical data. Most obviously, such information is incomplete. It is in the nature of things impossible to know every relevant fact about an historical period. Thus it is often necessary to infer possible or probable facts from what we do know. This is a general characteristic of the system. In a much stronger sense than that normal in natural language processing, its inferences are only probable inferences and its answers to questions, except in cases where some well-attested piece of information is asked for, are only probable answers.

Secondly the data is subjective. An authority reports what he believes to be the case, not what necessarily is the case. Sometimes this may lead him to report as fact something which is known, from other sources, to be actually false. And yet, since that false statement may affect other evidence, it must be represented in the data base. When this happens the false assertion is explicitly marked as such. A related problem arises with counter-factual conditionals. Many pieces of evidence take the form ' If such-and-such had happened (although it did not), the consequences would have been thus '. Evidence like this clearly gives important information and must be represented.

The subjectivity of the data gives rise to the further problem of contradictory data. It is quite possible to find one authority directly contradicting another. When this happens, each of the contradictory versions must be separately represented, and a special list kept of such contradictions. Then, when finding an answer to a question involves using a contradicted piece of evidence, the strategy which allowed the answer to be found must be repeated with each and all of the contradictory versions of the same evidence.

All this can be summarized by saying that the data is, in its very essence, uncertain, a fact which reinforces the aspect of question answering touched on earlier. The answers found are, often, plausible answers based on plausible inferences using uncertain data. This should not be interpreted as an excuse for producing random rubbish. The system is intended to provide specialists in the period with an interactive aid in their research. It must therefore perform at least as well as such a specialist working by hand in a mechanical fashion. This means that, whilst the system cannot be expected to have the intuition and general background of the historian, it must not give impossible or silly information.

\* The RESEDA project is supported by the Centre National de la Recherche Scientifique and by the Delegation Generale a la Recherche Scientifique et Technique ( contract 75.7.0456 )

The other difference between our basic material and that of more normal AI systems is that, being biographical, it deals primarily with the attitudes, beliefs and ideology in political and religious matters of the characters who are our concern. This means that the representation of the data base must be adequate to express abstract ideas and processes and that the inference algorithms also must take into account propositional attitudes. Thus they cannot depend on a tidy logic like that of the first order calculus. To illustrate this consider the following example : 'John dislikes apartheid and hence does not want South African rugby teams to play in England'. Most people would agree that there is some fairly strict causal relation between the two halves of this sentence, marked by 'and hence'. But whatever this relation is, it cannot be interpreted as material implication, since the converse 'John wants South African rugby teams to play in England and hence does not dislike apartheid' does not necessarily hold.

The issue becomes even more complex when it is considered that we are interested not only in finding relationships between people and the ideas they hold, but also in relationships between people. New relationships are established initially because a question has been asked the answer to which depends on inferring the new relationship. But when a new relationship has been found, it may be added to the data base by asking a 'system' question, providing that its validity has first been checked by an historian. Thus RESEDA is envisioned as a continually growing data base which itself proposes possible additions to its knowledge.

It is worth noticing that the sort of problems just discussed are not the result of using historical data. Anyone who tried to design a system dealing with modern american politics would be faced with exactly similar problems. Thus, if our examples with names like 'Pope Benoit XIII' and controversial topics like 'schism in the church' strike the modern ear oddly, it is worth remembering that 'Benoit XIII' could be replaced by 'Jimmy Carter' and 'schism' by 'the middle-east question' without essentially altering the basic problems discussed here.

#### Section 11 : representation of data

It should be said immediately that the level of 'understanding' aimed at here is not the 'deep' understanding of Charniak (Charniak 1977) and others. If someone takes a trip on a boat we are content to say simply that, without worrying about the exact description of the boat. This is not to denigrate systems using such very detailed knowledge. Simply their purpose is different.

On the other hand, some detailed knowledge which we do have is very specific to our data base. For example, 'civil war' refers only to the war between the Armagnacs and the Bourguignons, fought between 1392 and 1425 with the intention of gaining central power in France.

With this in mind, we can now take an example piece of text and see how it would be represented.

Figure 1a gives the french text. Figure 1b gives a somewhat Free translation of the same text; the numbers in square brackets mark a rough correspondance between parts of the text and the formal representation which follows later in figure 2.

'Les ambassadeurs de l'Universite etaient porteurs d'une lettre pour Benoit XIII, redigee precipitamment par Clamanges, redacteur habituel des lettres de l'Universite depuis 1394, le jour meme du depart (14 avril 1395). Cette lettre contenait presque une approbation des voies de concile et de convention. Il n'est pas etonnant qu'une lettre redigee en toute hate ait refleete les positions personnelles de son auteur plutot que celles preconisees par l'Universite. Ils avaient cru devoir la garder par devers eux. Quand ils furent de retour, l'Universite elle-meme prit soin de corriger cette epitre en en retranchant tout ce qui ne tendait pas a l'eloge exclusif de la voie de cession -26 aout 1395 (d'apres Valois 1891-1902, III pp. 70-71, Ornato 1969, pp. 25-26)

Figure 1a

The University's ambassadors [1,2] carried a letter for Benoit XIII [3,4] which had been hastily drafted by Clamanges [5], the regular drafter of University letters after June 1394 [6] on the same day as their departure (14 avril 1395) [5]. The contents of this letter [7] almost constituted approval of the way of general council (to resolve the schism) and arbitration (between the popes). It is not surprising that a letter drafted in great haste reflected its author's personal position rather than that advocated by the University [8]. They (the ambassadors) believed they should keep the letter to themselves [9]. When they returned the University took care to correct the letter [10,11], cutting out anything which did not lean towards approbation of abdication (by both popes) [12] (26 august, 1395) [11].

Figure 1b

#### General discussion of the representation

It is impossible to describe our representation fully in a paper of this length, even if we restrict ourselves to features exemplified in the representation of the text given in figure 1. However, some idea of its basic characteristics can be given fairly briefly. Figure 2 shows our representation of the text given in figure 1. The reader is not expected to be able to follow the representation at first glance; the rest of this section will be devoted to explanation. It should be noted too, that for reasons of clarity, the syntax of the representation used here differs from that used in practice (for a full description of the latter, see Bozzolo *et al* 1976). There is, of course, a strict correspondance between the two.

The passage is represented by a set of 'planes' one for each episode of the text. (For 'planes' in this sense, see Quillian 1968 and Scragg 1975). A brief english description of the contents of each episode precedes the plane representing it.

The predicate is the first element of the plane, followed by a list of its arguments (enclosed in the first set of braces), dating information

1. On the 14th april, 1395, an anonymous group of people, in Paris, held an official position in the University, at Paris.

```
[soc+cons+ETRE-AFFECTE {<SUJ=Vedettes-l Paris>
<OBJ=universite Paris>}
{(14-avril-1395) ()}
(Valois)]
```

2. This same group were members of a deputation.
 

```
<REL5 Vedettes-1 ambassade+membre>
```

[The relationship (being members of a deputation) 'specified in 2 is brought about by the episode reported in 3 (*correlator-pointer*) :

```
<CONFER 2 3>
```

3. The University of Paris sent a deputation to Benoit XIII at Avignon which left Paris on 14th april 1395 and returned sometime before 25 august 1395.

```
[DEPLACER {<SUJ=ambassade Paris>
<OBJ=ambassade Paris>
<SOURCE«Universite-de-paris Paris>
<DEST=Benoit-XIII Avignon>}
{(14-avr il-1395)(avant-25-aout-1395)1
(Valois)]
```

4. The deputation took an official letter from the University of Paris to Benoit XIII.

```
[DEPLACER {<SUJ=arabassade Paris>
<OBJ=lettre-officielle-l>
<SOURCE=Universite-de-paris Paris>
<DEST=Benoit-XIII Avignon>}
{(14-avril-1395) ()}
(Valois)]
```

5. Shortly before 14 april, 1395, Clamanges, in Paris, wrote this official letter from the University of Paris to Benoit XIII at Avignon.

```
[soc+ment+PRODUIRE {<SUJ=Clamanges Paris>
<OBJ=lettre-officielle-l>
<SOURCE=Universite-de-paris
Paris>
<DEST=Benoit-XIII Avignon>}
{(peu-avant-14-avril-1395)
(14-avril-1395)}
(Ornato)]
```

6. From june 1394 onwards Clamanges, as part of his official duties, drafted many letters on behalf of the University of Paris.

```
[soc+mult+ment+PRODUIRE {<SUJ=Clamanges Paris>
<OBJ*lettre-officielle>
<SOURCE=Universite-de-
paris Paris>}
{(juin-1394) ()}
(Ornato)]
```

7. On the 14th april, 1395, Clamanges, in Paris, expressed the idea specified in plane 8 (in the official letter already mentioned) to Benoit XIII as being, the idea of the University.

```
[soc+ment+DEPLACER {<SUJ=Clamanges Paris>
<OBJ=8>
```

(in the second set of braces) and finally the bibliographic source of the data.

```
<MODAL=lettre-officielle-l>
<SOURCE=Universite-de-paris Paris>
<DEST=Benoit-XIII>}
{(14-avril-1395) ()}
(Ornato)]
```

- \*8. (False). That the University of Paris supported Benoit XIII in his policy of arbitration.

```
[pour+AVOIR-ATTITUDE {<SUJ=Universite-de-paris
Paris>
<OBJ=Benoit-XIII Avignon>
<ARG=voie-de-convention>}
{(14-avril-1395) ()}
(Valois)]
```

9. Benoit XIII was not given the official letter by the ambassadors.

```
[neg+ETRE-AFFECTE {<SUJ=BenoTt-XIII Avignon>
<OBJ=lettre-officielle-l>
<SOURCE=Vedettes-l>}
{(14-avril-1395)(avant-26-
aout-1395)}
(Valois)]
```

- 9-Benoit's not being given the letter- was the result of Clamanges having falsely represented (in 7) the policy of the University (given in 11) (*correlator-pointer*) :

```
<CAUSE2 10 (C00RD2 7 11)>
```

10. On The 26th august,1395, the University re-wrote the official letter to Benoit XIII.

```
[rep+PRODUIRE {<SUJ=Universite-de-paris Paris>
<OBJ=lettre-officielle-l>
<DEST=Benoit-XIII Avignon>}
{(26-aout-1395) ()}
(Valois)]
```

- The re-writing (10) was the result of Clamanges having falsely represented (in 7) the views of the University (11) (*correlator-pointer*) :

```
<CAUSE2 10 (C00RD2 7 11)>
```

11. On the 26th august, 1395, the University of Paris wanted to inform Benoit XIII, in Avignon, of their position as expressed in 12.

```
[int+ment+DEPLACER {<SUJ=Universite-de-paris
Paris>
<OBJ=l2>
<DEST=Benoit-XIII Avignon>}
{(26-aout-1395) ()}
(Valois)]
```

12. Between 1395 and the beginning of 1408 the University of Paris opposed the Avignon popes on the subject of their policy of arbitration.

```
[contre+AVOIR-ATTITUDE {<SUJ=Universite-de-parisj
Paris>
<OBJ=papes-d ' avignon
Avignon>
<ARG=voie-de-convention>}}
{(1395) (debut-1408)}
(consensus)]
```

Figure 2

The planes of figure 2 make up the data base for the system. The data base is organised logically into 'volumes\*', with each volume containing references to all the planes representing episodes concerning one particular character (a 'star'). Since any particular episode may concern more than one star, a reference to the same plane may appear in several different volumes (cf. Scragg 1975).

The stars are the more important characters of the period, but are not necessarily individuals. For example, in the text given above, the following stars appear :

1. Benoit XIII and Clamanges, who are both individuals and therefore 'normal' stars.
2. The University of Paris, which is considered to be a 'moral' person. That is, it may take decisions, take part in juridical actions, own property etc, just like an individual person.
3. The Popes of Avignon. These are a 'collection' of characters, defined extensionally.
4. The delegates from the University to Benoit XIII. The REL5 (in plane 2) specifies that this group of people were all members of the same deputation to Benoit XIII. By its nature, the group is temporary. How long such a group lasts and the events in which the group is involved is shewn by attaching the REL5 plane to the plane reporting the episode which brings the group into existence (done by the CONFER correlator-pointer). In the case of REL5, any relevant plane which has 'deputation' as its SUJ, gives further information about this particular group (for example, plane 4).
5. Vedettes-1 (Stars-1). There are several anonymous groups like this. One volume serves for all such groups, who are distinguished one from another by the index number after vedettes.

Each plane, apart from the RELATION plane already mentioned, also contains dating information. The two-element list towards the end of the plane gives the date at which the episode starts followed by the date when it finishes. Thus, if we take plane 3 as an example :

{(14-avril-1395)(avant-25-aout-1395)}

tells us that the deputation left Paris on the 14th april and returned before the 25th august, 1395. Dating is not always as simple as this. If the action of the predicate continues over a period of time, more than one date may be given. For example, in 'it is known that he was Canon at Lille in 1398, and he is addressed by the same title both in 1390 and in 1391' it is important to record all three dates.

The last item in each plane is the bibliographic source from which the episode is taken. In plane 3, our authority is Valois'treatise cited in figure 1.

Place information is very important, and is treated by attaching to each of the chief arguments of the predicate a location slot, which is filled when the physical location of the instantiation of that argument is known. Thus, to use plane 3 as an example again, <SUJ=arabassade Paris> tells us that the deputation was in Paris at the beginning of the

episode <OBJ=ambassade Paris> that it was also in Paris at the end of the episode. (This interpretation is partially determined by the predicate used, as will be discussed later). The SOURCE of the episode (University-of-paris) is also in Paris, and the DESTINATION, Benoit-XIII, in Avignon. Not all arguments to the predicate may have their location specified : only SUJ, OBJ, SOURCE, DESTINATION and ARGUMENT. As with dating, it may be sometimes necessary to specify more than one location for a given argument.

When the description proper of an episode is considered, the most characteristic is that it consists of a predicate with arguments. Of the arguments (called by us correlator), six correspond more or less to conventional cases : SUBJECT, OBJECT, DESTINATION, MODALITY and ARGUMENT. Others, like CAUSE2, COORD2 and CONFER in the example text, are peculiar to this representation. In general, it would be a mistake to identify any of the correlators too strongly with conventional cases: the 'meaning' of a correlator is given in the specialist program attached to the predicate governing the correlators and which makes use of the correlators when doing inferences. Their names can give only a very rough intuitive feel for what they mean.

Not all correlators are obligatorily present, even for the same predicate (cf. planes 7 and 11, where the predicate is in both cases DEPLACER (to move) modified essentially in the same way, but where the correlators are different). Thus, when a particular correlator is used, its name must appear. Rigid rules specify the argument frames for each predicate, determining not only what correlators must appear in a particular argument frame for that predicate or its modifications, but also what sort of entities can fill any particular argument. The argument frame for 'rep+PRODUIRE' is a fairly simple example :

[rep+PRODUIRE {<SUJ=Vedette> <OBJ=lexical item>}]

specifies that 'rep+PRODUIRE' (which can be roughly translated as 'to re-do' or 'to correct') must have at least two correlators SUJ and OBJ and that the SUJ slot must be filled with a star, the OBJ slot by a lexical item.

The predicates themselves should now be considered. There are at the moment only five, although nothing is fixed or magical about the number. Although we intend to keep the number of predicates as small as possible, more may well prove necessary. DEPLACER (to move), AVOIR-ATTITUDE (to have an attitude), PRODUIRE (to produce), ETRE-AFFECTE (to be affected by) and ETRE-PRESENT (to be present) are chosen to be mnemonic. Nonetheless they correspond only minimally to the normal use in natural language of the same verb. Once again, the real meaning of the predicates is given by the specialist attached to each predicate. A better idea of what the predicates represent will be gained when we do, finally, take a closer look at the example planes.

Intuitively, five predicates alone are not adequate to represent the sort of complex data with which we want to deal, and a few minutes experimentation with the example text will soundly reinforce intuition. A set of 'modulators' are therefore used to modify the sense of the predicate, (cf. Mel'chuk Zholkovskij 1970). These modulators, in the graphic

representation used in this paper, appear in small letters to the left of the predicate, attached to it by a + sign. The 'rep' in the argument frame above is, in fact, a modulator, and adds a sense of 'doing over again' to the basic 'produce' sense of PRODUIRE. Another example can be found in plane 5, where 'ment' adds a sense of 'intellectual activity' to the same predicate. Modulators may be combined, as in plane 6, where 'soc+mult+ment' attached to PRODUIRE add, respectively, the notion that the action of the predicate is part of the career of the SUJ (soc) (i.e. the sort of thing he might put in his curriculum vitae), that the action is an action done before, may be several times (mult), and the same notion of intellectual activity just discussed (ment).

#### Discussion of the planes

After this rather lengthy general discussion, we now have sufficient background to look at the representation of the example text in some detail.

Plane 1 needs very little comment. Vedettes-1 has already been explained. The predicate 'soc+const+ETRE-AFFECTE' with an object attached does, however, deserve some explanation. The 'soc' simply says that the being-affected was, in some way, part of the official career of the ambassadors, 'const' is a little more complicated. The predicates are essentially static in their nature, so there has to be some way of representing changes of state (cf. Abelson 1975). This is done by three modulators : incep, fin and const, 'incep' marks the creation of a new state, 'fin' the end of the state, 'const' that the state is, at the time specified, in full force. All three relate to the first time slot in the plane. When any one of the three is present in the descriptive part of the plane, the second time slot remains empty. Thus plane 1 does not tell us that a group of persons were given a position on april 14th, but that by that date they already had the position.

The use of OBJ in plane 1 illustrates one situation where a correlator does not map in a obvious way onto a conventional case with the same name, and of how the meaning of any particular correlator is in part determined by the predicate with which it is associated. ETRE-AFFECTE is used when the OBJ can be conceived of as being, at least temporarily or provisionally, a characteristic of the SUJ.

'universite' (unlike the 'moral' person Univer-site-de-paris) is a lexical item, which means that its meaning is defined not by a program (as is the case with predicates, correlators and modulators) but by relationship with other lexical items (Ornato, Zarri 1976).

Plane 3 is fairly clear. DEPLACER (to move) is always transitive, and always involves a sense of actual distance covered. The modulator 'ment' is used when it is something expressed (by means of a letter or whatever) which is 'moved' from the SUJ-ject to the DESTination (cf. plane 7). If a SOURCE correlator is used with DEPLACER unmodified, it is interpreted as 'at the instigation of. Similarly, in plane 5, the SOURCE with 'ment+PRODUIRB' can be interpreted as 'on the orders of or 'on behalf of.

Plane 7 offers an example of the use of a 'completive' plane. The OBJect is itself described by an independant plane, whose number fills the OBJect

slot. The completive plane itself, plane 8, is marked with an asterisk to shew that the assertion it represents is false. As was said in the introduction, this is a situation common in dealing with our type of data. The inference routines too must take account of false assertions.

The <CAUSE2 10 (COORD2 7 11)> appearing after plane 9 is (like the CONFER line after plane 2) an indication of relationships between planes. COORD2 associates two planes of the same overall type which are both governed by the same correlator-pointer. In fact, COORD2, and its parallel correlator COORD1 which functions inside planes, are equivalent to first order predicate calculus 'and', with the restriction that only similar things may be conjoined. Another pair of correlators, ALTERN1 and ALTERN2, are equivalent to exclusive 'or'.

CAUSE2 specifies that its first argument is the result of its second argument. A parallel correlator-pointer FINAL is used when the result of an episode seems probable but is not yet confirmed by the evidence so far available. For example, 'Charles VI sent the Comte de St. Pol to arrest Pierre d'Ailly at Cambrai' would give rise to three planes, one reporting that Charles VI sent the Count to Cambrai, another that the Count arrested Pierre d'Ailly, and the third that Pierre d'Ailly was, at some time later, in prison. But the latter two planes would be marked as only probable by the use of FINAL instead of CAUSE2 to link these three planes together. RESEDA is a very cautious inference maker. It will not make inferences based on probable information. On the other hand, if a plane marked as probable is later confirmed, it will be up-graded to certain by changing the pointer and the order of the arguments.

The remainder of the coding contains very little that has not been already commented on. Plane 11 introduces a new modulator 'inf which gives a sense of intention or of 'wanting that' to the predicate to which it is attached.

AVOIR-ATTITUDE in plane 12 means, roughly, 'feels about' or 'has an attitude towards', and the modulator 'contre', used only with this predicate, makes it into 'opposes'. AVOIR-ATTITUDE gives us a good example of how one predicate can be used, with appropriate modification, to represent quite subtle notions. As one might expect, it bears most of the burden of representing relationships between people. With appropriate modulators and argument frames it has been used to express all of the following :

Someone supports (opposes) someone (optionally, about something).

Someone promises (threatens) someone with something

Two (or more) persons are involved in litigation (in opposition or on the same side) concerning some matter.

Two (or more) persons oppose each other by violent means.

Someone (not immediately involved), supports or opposes someone in a legal matter.

Someone wants something to come about.

Section 111 : using the data base  
to answer questions

As was said earlier, the sort of understanding we are aiming at is not the very deep detailed understanding of some other systems. Nonetheless we hope to be able to answer most of the type of questions a historian would be likely to ask about the people mentioned in our data base. This involves an attempt to write deduction programs based on human attitudes and motives, and is, we think, sufficiently difficult and of sufficient intrinsic interest to warrant the degree of effort involving in constructing RESEDA.

The main burden of the inferencing is carried by the specialists attached to each predicate. Even if it were worked out in full detail for all five predicates, it would be clearly impossible to give a full description here. But it seems worthwhile to take one single question, imagining that the data base is as given earlier (i.e. just the representation of our example text, with some more detail attached to the lexical items involved) and shewing how the inference routines would find the answer to that question.

Let us imagine that a user asks  
'Why did Clamanges, after august 1395, completely give up his activity as official secretary to the University of Paris ?'  
This would have to be coded, since natural language input is not allowed, in the same formalization as that used for the data base :

[fin+soc+mult+ment+PRODUIRE {<SUJ=Clamanges Paris>  
<OBJ=lettre-officielle>  
<SOURCE=université-de-paris Paris>  
<CAUSE1=?>}  
{(après-août-1395) ()}]

Figure 3

CAUSE1 is the equivalent within planes of CAUSE2 between planes; here its value is simply a question mark, shewing that the information required by the user is the value of that argument. For the rest, the representation matches that of the data base, except that no bibliographic authority is specified. So the predicate and its instantiated arguments give the known information, the ? shews what is required.

If a plane existed in the data base which matched, item by item, the question, the answer would be found directly, and the plane or lexical item in the ? position would give the user the information he wanted. Direct match here is a little more complicated than is often the case : if one of the items being searched for is a lexical item defined by a tree structure (see Ornato, Zarri 1976) the search is generalized upwards in the definition tree. No such directly matching plane exists in the present case.

Therefore the specialist attached to PRODUIRE is called upon. (It is always the predicate contained in the question which determines the specialist to be tried). The modulator 'fin' and the empty CAUSE1 correlator attached to PRODUIRE together tell us that we are seeking the cause of an interruption in the predicate activity. The modulator 'maent' adds

the additional information that what is involved is an intellectual activity. This points us to a sub-part of PRODUIRE which gives information about PRODUIRE as an intellectual activity, including aspects like possible reasons for terminating the activity. There we find that if 'soc' is also attached to the predicate and if SOURCE is present in the question, then we are justified in assuming that the SOURCE delegates power to the SUJ. All this leads to the formation of an hypothesis 'someone stopping working for someone else -in a situation involving the delegation of intellectual power- may be the result of the employee, who represents the employer, acting, in the course of his official duties, in a way not consonant with the official views of his employer<sup>1</sup>. (Employee and employer are here used only as shorthand for 'someone representing an official body' and 'the official body represented' : no money need change hands).

This hypothesis is tested by searching in the data base for episodes which fit the suggestion that Clamanges may have acted in such a way with regard to the University of Paris.

The search is done by trying to find in the data base planes which match the schemata given in figure 4, which represent a formalization within RESEDA of the hypothesis given above. After the formal representation, an english transcription of the schema is given.

p [soc+ment+DEPLACER {<SUJ V1>  
<OBJ q>  
<SOURCE V2>}]

!q [pour/contre+AVOIR-ATTITUDE {<SUJ V2>  
<OBJ V3>  
<ARG a>}]

!r [contre/pour+AVOIR-ATTITUDE {<SUJ V2>  
<OBJ V3>  
<ARG a>}]

s [ment+DEPLACER {<SUJ V2>  
<OBJ r>  
<DEST V4>}]

p= The subject (V1) of the original question, as part of his official duties, says something represented in plane q on behalf of the SOURCE in the question (V2).

!q= The SOURCE of the original question (V2) is in favour of (opposed to) some person (V3) on topic a (contradicts r).

!r= The SOURCE of the original question (V2) is opposed to (in favour of) some person (V3) on topic a (contradicts q)

s= The SOURCE of the original question (V2) says to some person (V4) whatever is expressed in plane r.

Figure 4

V1 and V2 are, respectively, the SUJ and the SOURCE of the original question, V3 and V4 are other, unspecified characters who may turn out to be the same person, q and r refer to instantiated

versions of the schemata with the same name and a is a variable. The exclamation marks before q and shew that they are contradictory (i.e. if 'pour' appears in one 'contre' must appear in the other). Obviously the dating of any planes found must fit with the question and with the other planes.

In our present case, where the data base is as shewn earlier, p and q are satisfied by planes 7 and 8. Plane 8, it will be remembered, was marked as false by the use of an asterisk, and indeed plane 12, which flatly contradicts 8, also satisfies r above. The particular form of the contradiction -plain falsity vs. established truth- allows us to conclude that it is unnecessary to search for a plane to satisfy s. s is there to cater for the most general case, where the two planes satisfying p and q are simply contradictory but neither is known to be downright false. In that case, one must find some evidence (plane s) that V2, the original SOURCE, has informed some other person of whatever is reported in r. But if, as in this case, the attitude of the employer is well known, there is no need to search for other evidence.

Even after episodes have been found which support the hypothesis, it is not given to the user as a definite answer before an attempt has been made to verify it by finding some concrete action done by the employer against the employee to shew that what Clamanges did, was in fact sufficient to account for a break in the relationships between him and the University. In other words, we search for immediate reactions of the University against Clamanges\*action. The inference rules give a number of conditions which are grounds for assuming a concrete manifestation of disagreement with someone. To remove a living from someone, to forbid the publication of someone's book, to contest someone's authority, for example, are all possible grounds. Amongst these conditions 'rep+PRODUIRE' (re-doing something) appears as one possible equivalent to 'real+contre+AVOIR-ATTITUDE' (the concrete manifestation of disagreement), providing that the SUJ of 'rep+PRODUIRE' was the SOURCE in a plane where the OBJ was the same as that of the 'rep+PRODUIRE' plane. The SUJ of the plane containing the SOURCE is the OBJ of the AVOIR-ATTITUDE plane.

In order to make use of this rule, we first look for any CAUSE2 pointer which contains p, i.e. 7, as its second argument. This gives us two planes, both 9 and 10 are said to be caused by 7 (and by 11, but we are only interested now in 7). 10 has Universite-de-paris as SUJ and tells us that the University corrected the critical letter. This gives us the verification we need. If even more confirmation had been required, 9 would have provided it.

In the present version of RESEDA, the specialist programs for the predicates use a collection of fairly ad-hoc rules. Although this preliminary model despite its limited number of rules allows us to make a many useful inferences within predefined contexts, we hope to develop a more flexible and more unified version. But it is clear that any further development will depend heavily on the empirical work done in the first stage described here,

## Conclusion

RESEDA, the system described informally here, is an attempt to apply well-established techniques from the domain of Artificial Intelligence within a useful application, whilst at the same time developing new inferences rules to account for the peculiarity of the data. It is hoped that the representation and inference methods developed in the design and implementation of this system will prove sufficiently supple to deal with any kind of biographical data. Ghosts are not necessarily old-fashioned.

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