BUILDING THE INFERENCE COMPONENT OF AN HISTORICAL INFORMATION RETRIEVAL SYSTEM

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ABSTRACT

The principal characteristic of the RESEDA system is being able to question an historical database about the causal relationships which may exist between different attested facts in the database, but which are not explicitly recorded. In order to do this the designers of RESEDA have created from scratch a methodology for the formalization and generalization of the reasoning used by historians in concrete situations. The description of the present state of this methodology is the object of this paper.

I   INTRODUCTION

The aim of the RESEDA project   is the construction and practical exploitation of a database of biographical information dealing with the lives of a certain number of important people in France during the late Middle Ages* The principal characteristic from an AI point of view is being able to question the system about causal relationships, which may exist between different attested facts in the database, but which are not explicitly recorded. If the replies are considered plausible by the user-historian, then the new causal relationships can be permanently recorded in the base. Thus the system may be progressively improved by use.

To carry out these inference operations, RESEDA uses two additional sets of data besides the biographical information proper. These two sets of data constitute the system's "general knowledge" of its particular field. The first gives the historical background for the period; for example, information on the social, economic and bureaucratic etc. structures of late French mediaeval society, information about important events (e.g. the "hundred years war"), ideological trends etc. The

second set consists of "common sense" rules, which form the backup for the Inference.procedures. These permit, for example, top-level changes in the State administration to be explained in terms of changes in political power.

Therefore RESEDA utilises knowledge inherent to a well-defined subject area to achieve the concrete objective of simulating an expert's behaviour within this field; hence it may, in some respects, be compared to systems designed on the principles of "knowledge engineering" [1]. This coherence of purpose is also reflected on a more technical level : for example, the format and method of activating the inference rules used by RESEDA conforms to the general theoretical framework defined by the "consequent theorems" of PLANNER [2] as do rules of the "situation-faction" type used by most expert systems .

However, RESEDA has certain special characteristics which are unusual in most expert systems, such as MYCIN C3], PROSPECTOR [4], etc.

a. The specialized knowledge which must be introduced into the system is characterized by the total absence of any systematization or formalization - who indeed may claim to know the laws of history ?

b. The information that RESEDA is required to process refers mainly to "abstract notions", such as the political and religious attitudes, beliefs and ideology of the people concerned [5], rather than "concrete objects" like bacteroides, igneous rocks or nuclear submarines. Therefore RESEDA has some characteristics in common with the "belief systems", as defined by Abelson [6] in opposition to "knowledge systems". Abelson emphasizes that "belief systems have not been very popular objects of study in AI" [6:360]; indeed, it would be difficult to cite many projects which share a substantial numbers of RESEDA'S objectives, even taking into consideration, for example, the studies of Carbonell [7;8] and Kolodner [9],

These characteristics do not make it easy to identify the knowledge necessary to construct the system, particularly in the case of the common sense rules. To avoid falling into the trap of constructing these rules a priori from an abstract point of view, which could only lead to a dangerous hypersimplification - see the famous example of the "Berlin Wall" C7:27] - the designers of RESEDA

have decided to emphasize the principle that all information to be introduced into an expert system must be obtained by reproducing the actual behaviour of specialists within the given field. This means that any inference rule used in RESEDA is only a formalization and a generalization of the reasoning, or a part of it, effectively used by an historian in a concrete situation [10;11]. The RESEDA team has created an entire methodology from scratch for representing historical reasoning, which has been progressively refined throughout the course of the project. It is the description of its present state which is the object of this paper.

II FUNDAMENTAL CONCEPTS OF THE RESEDA SYSTEM.

The biographical information which constitutes the system' s database is organized in the form of units called "coded episodes'* or "planes". There are several different types of plane; the "predicative plane**, the most important, corresponds to a "flash" which illustrates a particular moment in the "life story" of one or more persons. A predicative plane is made up of one of five possible "predicates" (BE-AFFECTED -BY, BEHAVE, BE-PRESENT, MOVE, PRODUCE), to which one or more "modulators" may be attached. The modulators' function is to specify and delimit the semantic role of the predicate. Of course, the "meaning" of the modulator plus predicate is "defined" - as for all elements of the RESEDA data definition language ("metalanguage") - by the general behaviour of the system rather than by the usual function of these codes in natural language - see also Hayes [12:11-12]. The predicate of the plane is accompanied by "case slots" [13/14] which introduce the predicate arguments.

Dating and space location information is also given with a predicative plane, as is the bibliographic authority for the statement. Predicative planes may be linked either through the label of one plane being the value of an argument slot (the slot OBJ) in another, or through explicit links "and", "or", "cause", "finality" etc.

The extremely simple example fiven in figure 1 should provide a clearer idea of what I have just explained; it is the representation of "Robert de Bonnay was named b a i l l l of Macon on 27th September 1413 by the King's Council" (bibliographic authority : Demurger ; the "b a i l l l" was an officer who dispensed justice, administered finances, etc., for a particular area, "ballliage", in the name of a king or lord).

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1) incep+BE-AFFECTED-BY SUBJ    Robert-de-Bonnay
                        OBJ     bailli:Mâcon
                        SOURCE  king's-council:Paris
                        date1 : 27-september-1413
                        date2 :
                        bibl  : Demurger!,234

                        Fig. 1
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The codes given in capital letters indicate the predicate and the cases associated with it. For each predicative plane there is a pair of temporal markers, "datel - date2", which give the duration of the episode (the predicates are, therefore, "state" predicates). In the above example, which

concerns only the beginning of a state (modulator "incep"), "date2" is obviously empty. "Robert de Bonnay" is a "vedette",i.e. one of the historical persons whose "life story" is recorded in the system ; "bailli" (meaning the "post of bailli") and "king's-council" are entries in RESEDA'S lexicon. The classifications associated with the lexical terms provide essential information for the system as regards the historical background of the period. "MIcon" and "Paris" are obviously the "object location" and the "source location" respectively. If the historical documents give us explicitly the precise causes of this nomination, then the corresponding planes would be introduced into the database and the "nomination" plane would be associated with them by an explicit link of the "CAUSED-BY" type.

When the system is considered from the point of view of its utilization, the fundamental concept which must be introduced is that of the "search model".

A "search model" gives the essential elements, expressed in terms of the RESEDA metalanguage, of a coded episode which it is necessary to search for in the database. A search model may originate from outside the system, if it is the direct translation of a query posed by a user. On the other hand, it may be automatically generated by the system. This happens during a search for "causes" when one tries to retrieve the planes which supply the presuppositions of a certain known episode. A search model may, Independent of its origin, be "transformed" into a semantically "equivalent" model if an impasse is reached while trying to match the model with data in the base.

Let us suppose, then, that the user questions RESEDA on the subject of the progression of Robert de Bonnay's career, asking, for example, "Did Robert de Bonnay exercise the power of a b a i l l i during the first quarter of the 15th century". In this case the user himself creates the search model given in figure 2, with aid of a prompting program.

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BE-AFFECTED-BY  SUBJ  Robert-de-Bonnay
                OBJ   bailli
                bound1 : 1400
                bound2 : 1425

        Fig. 2
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The only notable difference between this formalism and that required for representation of the episodes in the database is that of the presence of a "search interval", "boundl - bound2", which is used to define the temporal limits of the search. Therefore, the search interval has the function of limiting the planes to be examined, and has only an indirect relationship with the temporal information of the "date" type which is associated to each of the episodes recorded in the base.

I do not intend, here, to go into the details of the procedure adopted to test the match of a search model with data in the base ; instead, for details of this, see Zarri et al. [15;16]. It is, for example, obvious that the model in figure 2

may be directly matched with the plane in figure 1 ; this of course is the exception rather than the rule.

In the "case of a dead end, a first class of inference rules may be applied to the model, that is the "transformations". To keep to an extremely simple example, the search model :

    (for+BEHAVE   SUBJ x   OBJ Y) =
        "to be favourable towards..."
could be substituted by the model :
    (against+BEHAVE   SUBJ x. OBJ Y)
given that information regarding the unfavourable attitude of person X toward person Y is at the same time a response to any query about the possibility of a favourable attitude. Note the existence of an underlying common sense rule even in such a simple transformation.

A second example of a transformation is that given in figure 3. The underlying common sense rule is : "if a person x_ has a university degree W, then this person has followed some course v" (one or several persons Y have "produced" the course \r with the intention of x). In figure 3, I have only partially detailed the "restrictions" associated with the "variables" X, Y, V and w;

t1)	PRODUCE SUBJ y ➡ BE-AFFECTED-BY SUBJ x
	OBJ v OBJ w
	DEST x

    x = <vedette>
    y = <vedette>|<vedettes>
    x ≠ y
    v = <university-course>
    w = <degree-obtained>
    w = f(v)

                    Fig. 3

the use of variables allows maximum generality in the formulation of the common sense law underlying the transformation. The values which replace the variables in the retrieved plane (or planes) using the transformed model must obviously respect these restrictions ; for example, the particular type of "degree" which will have been substituted for w must be compatible with the value of v_ in the original model, which I have indicated for simplicity as w = f(v).

Unlike the transformation "for/against" given earlier, the transformation in figure 3 is "one-way", that is, it is possible to transform the model from left to right, but not the inverse.

Very often the passage of one model to another is subject to certain conditions ; it is only possible to substitute one model for the other if a particular condition has been satisfied. This is verified by checking the existence of episodes within the base which are able to guarantee the appropriate context.

Figure 4 shows the formulation in natural language of two fairly simple conditional transformations. It is clear that, in the cases of "conditional" transformations, the "semantic distance" between the information found using the transformed model and that sought at the outset may be quite large. In the most general case, therefore, the

t2) try to verify the attachment of x to the important person z ⬌ try to verify the attachment of y to the important person z on the condition that : verification of a fairly close relationship, for example kinship, between x and y may be found

t3) try to verify that x belongs to party v ➡ try to verify that x fights against party w on the condition that : it is possible to show that, during the period in question, v and w (e.g. Armagnacs and Bourguignons) were openly opposed

                    Fig. 4

information retrieved by means of the transformed model is designed to suggest possible new semantic associations rather than a real reply to the search procedure originally instigated.

Even taking into consideration this first category of inference rules, the behaviour of the system such as it has been described up to now is entirely classic in type. RESEDA has, however, a second, more original method of research : it is possible to search for the "causes" of an attested fact in the base. For example, if the user, in submitting the query in figure 2, obtained in reply the plane in figure 1, he would be able to continue his enquiry into the career of Robert de Bonnay by asking the system if it knows the reasons for his nomination as "bailli" of Macon. If the "causes" are not explicitly registered in the system, the function of replying to this type of query is the domain of a second category of inference rules, the "hypotheses".

In order to give some idea of the functioning of the hypotheses on an intuitive level, figure 5 shows the formulation in natural language of four of the hypotheses which are at present in the system.

The first part of each of these rules corresponds to a particular class of confirmed facts (planes) for which one asks the causes. For example, the plane in figure 1 is clearly an exemplification of the first part of the fourth hypothesis in figure 5. In RESEDA's terminoloqy, the formal redaction of this first part is called a "premiss". The second part (the "condition") gives instructions for searching the database for information which would be able to justify the fact which has been matched with the premiss. That is, if planes matching the particular search models which can be obtained from the "condition" part of the hypothesis can be found in the database, it is considered that the facts represented by these planes could constitute the justification for the plan-premiss and are then returned as the response to the user's query.

Figure 6 gives the planes obtained by means of the condition part of the fourth hypothesis in figure 5 in the case of the query about Robert de Bonnay's nomination. The following chapter will be devoted to the steps which, by generalizing and formalizing the observations of the historian,

allows the final formal realization of such a hy-
pothesis.

... one might cease to act on behalf of some
other person
                    IF
one has abused that person's confidence (e.g. by
misrepresenting his views to a third party)

... one might leave something (in one's will) to
a (religious) community
                  BECAUSE
one had some special connection with this commun-
ity

... one might take a particular attitude in an
argument
                    IF
one has close links with one of the parties in a
conflicting situation

... one mights be chosen for a (official) post
                  BECAUSE
one is attached to a very important personage who
has just taken power

Fig. 5

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2) BE-AFFECTED-BY SUBJ   prince's-court(SPECIF
                          Charles-d'Orléans): Blois
                 OBJ   Robert-de-Bonnay(SPECIF
                          chamberlain)
                 date1 : 8-april-1409
                 date2 : (1415)
                 bibl : Demurger1,234

"Robert de Bonnay held the post of chamberlain
to the Duc d'Orléans (the court of Charles
d'Orléans, who has his residence at Blois, was
'augmented' by Robert de Bonnay) from 8 april
1409 until 1415 (date not confirmed by docu-
ments, but reconstituted by the historian)".

3) incep+lid+BE-AFFECTED-BY SUBJ king's-council:
                                  Paris
                 OBJ   (COORD Louis-d'An
                        jou Charles-
                        d'Orléans Jean-
                        de-Bourbon
                        Dauphin-Louis
                        Jean-de-Berry
                        Bernard-d'Arma-
                        gnac) : Paris
                 date1 : 1st-september-
                          1413
                 date2 :
                 bibl : consensus

"On the 1st September 1413, the leaders of the
faction favorable to the Duc d'Orléans (the
future 'Armagnac party') took control ('lid' =
leader) of the administration of the state.
This information is provided by the 'consensus'
of historians, who are specialists in this
period".

Fig. 6

III THE FORMALIZATION OF HISTORICAL REASONING

I will restate here the general principles of
the methodology which were adopted from the begin-
ning of the project with the aim of providing
RESEDA with inductive inference rules of the "hy-
pothesis" type [10]. There are three well-defined
stages :

a) the identification of a possible user-
question of the type "cause" which cannot be sat-
isfactorily answered either by direct matching
with the data present in memory or by an inference
procedure already contained in the system, but
where the specialists in mediaeval history are
capable of picking out planes from RESEDA's data-
base containing data which may indirectly provide
the information needed for the reply.

b) On the basis of this information and the
logical relationships among the planes found, the
analyst tries to produce a formal "condition", or
sequence of theoretical schemata of planes ("con-
dition schemata"), which correspond to the par-
ticular planes pointed out by the historian and
all other planes which could provide an answer in
analogous situations. The condition must be able
to explain all the specific realizations of the
"premiss", that is, of the general scheme under-
lying the coded episode whose causes were orig-
inally requested. The "premiss", the "condition",
and their "variables" and "restrictions on the
variables" together make up the formal "hypoth-
esis".

c) Once this classic line of inductive reason-
ing [17] has been worked out, then the semantic
type of the empirically discovered hypothesis is
determined and a "name" is then given to the hy-
pothesis (for example, for the fourth hypothesis
given in figure 5, we have "the hypothesis of nomi-
nation following a change of government").

If this methodology is applied strictly, it
gives rise to at least two types of major incon-
venience .

d) From the general point of view, the growth
of the corpus of hypotheses is purely random and
cumulative : each hypothesis is constructed as a
single unit, totally independent of other inference
rules in the system. Thus, a posteriori, many par-
tial overlaps can be discovered (several inference
rules have indeed recourse in an independent way
to some general principles, such as that of "con-
tradiction") , as are redundancies on the condition
schemata level of the same hypothesis (several
schemata express the same concept with slight sem-
antic nuances, for example, see the "hypothesis of
the donation" in Zarri [11]).

e) On the strictly practical plane, the sys-
tematic insertion at the condition level of all
data discovered by the historian, rapidly leads to
an important complication on the formal plane. The
exponential growth of possible relationships be-
tween different elements of the hypothesis in
effect forces the introduction of innumerable vari-
ables and very complicated restrictions, see for
example, the "hypothesis of coherence of role"
[10:237-240]. This can only imply considerable
delays on the level of the effective execution of

the procedures.

In order to illustrate how it is possible to use principles a) b) and c) in the most flexible and productive way, I will now give a detailed example. While examining a recent work by Alain Demurger [18] on the civil war in France and the changes of administrative personnel in the kingdom during the period 1400 to 1418, the two historians, Monique Ornato and Joanna Pomian, who are both working on the RESEDA project, encountered the quotation reproduced in figure 7, extracted from a letter from King Charles VI appointing Regnault d'Azincourt as "bailli" of Gisors [18:168]. This letter alludes to one of many episodes of the civil war, the purging of the central administration, which took place between September 1411 and January 1412, by the Duc de Bourgogne, who at that time was securely in power.

"Et nous avons esté et soyons souffisamment informé que Robert Le Maistre qui détient et occupe l'office de bailly de Gisors, a tenu et tien le parti desdits de Berry, d'Orléans et de leurs aleez et en leurs mauvais et dampnable propos les a conseillez, portez, soustenuz et favorisez par quoy il sest entre autres choses rendu indigne de tenir et exercer le dit office de bailli ne aucun autre office quelconques. Et pour ce l'en avons privé, débouté et déchargé, privons, déboutons et deschargeons de tout par ces présentes..."

"We have been informed and are now acquainted with the fact that Robert Le Maistre, who holds the office of bailli of Gisors, has supported and will continue to support the Dukes of Berry and Orléans, and their allies; he has advised, encouraged, supported and favoured them in everything concerning their malevolent and condemnable intentions. For these reasons he has become, among other things, unworthy to occupy and exercise his functions as bailli or any other public function. We have, therefore, deprived, rejected and discharged him from his duties and now, by this act, we deprive him of everything..."

Fig. 7

The information given in figure 7 corresponds to a situation where all the data related to a "cause" search already exists in the base, explicitly linked together ; therefore, a query relating to the nomination of Regnault d'Azincourt might receive a reply by direct match. On the basis of this model, our historians have thus been able to establish that, within the context of coherence of local power with the governmental power during an unsettled period, all information concerning the following should be retained as interesting :

f) the accession to power (in the case of the preceding example, the Duc de Bourgogne) or the loss of power (the Ducs de Berry, Orléans, etc.) ;

g) the accession to (Regnault d'Azincourt) or the loss of (Robert Le Maistre) power on a local level ;

h) the existing relationships between the people thus brought into play.

We can, now, return to the query on the subject of the reasons for the nomination (Fig. 1) of Robert de Bonnay as bailli of Mâcon. Documents of the period, and this is confirmed by Demurger [18: 234-235] do not mention these reasons ; therefore, we find ourselves in the situation foreseen by a) above. Our historians have thus tried to isolate information in RESEDA's database allowing an indirect reply to the query ; in our case, this information is going to conform to suggestions f), g) and h) obtained by means of the prototype situation. In figure 8, I have given the list of natural language formulations corresponding to the planes thus obtained ; I must point out that for the sake of simplicity, I have not indicated all the information of type "h" that it is possible to extract about reciprocal relationships between the people involved. The planes corresponding to the information of the type "f" obviously pertain to this part of the database which supplies the general historical background of the period.

f1) The influence of Duc Jean de Bourgogne on the King's Council ended on 23rd August 1413, thanks to the energetic efforts of the Dauphin Louis.

f2) The leaders of the Orléans-Armagnac faction took complete control of the King's Council 1st September 1413 (see the coding of plane 3 in the preceding chapter).

g1) On 17th September 1413, the King's Council removed Philibert de St Léger from his post as bailli of Mâcon.

h1) It has been established that, in March 1414, Philibert de St Léger was in command of the garrison which the Duc de Bourgogne had left at Compiègne.

h2) From 1406 to 1411, the Duc de Bourgogne paid Philibert de St Léger an allowance.

h3) During the same period, Philibert de St Léger was counsellor and "maître d'hôtel" of the Duc de Bourgogne.

h4) Robert de Bonnay held the post of chamberlain of the Duc d'Orléans from 8th April 1409 until 1415 (see plane 2).

h5) On 9th October 1411, Robert de Bonnay signed the proclamation of the captains of the Orléans party.

Fig. 8

According to the criteria given in point b) at the beginning of this chapter, the general schemata obtained by abstraction from the planes corresponding to the information in figure 8, should together now constitute the condition part of a new hypothesis, whose "premise schema" is derived from plan 1 in figure 1. First of all, our historians tried to see if it was possible to simplify the information in figure 8, eliminating by transformation the "duplicated" information. This allowed the elimination of h1) and h2), to leave h3), and h5), to leave h4) ; they have, therefore, retained information which is not cluttered with useless details, and which constitutes the "archetype" of the concept of "attachment to an important person". It

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should be noted that the expression "eliminated" is not strictly correct ; if the transformation allowing the execution of this type of simplification do not yet exist in the system, they are now created and added to the general corpus of transformations. All that remains now is to organise the logical relations between the premiss and the information contained in figure 8. A "natural" way of regrouping the remaining planes in figure 8 is now given in figure 9. The logical operators "∧" and "∨" have the usual meaning "and" and "or". On the one hand,

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(f2 ∧ h4) ∨ (f1 ∧ g1 ∧ h3)
Fig. 9
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the attestation of the accession to power of the princes of the Orléans party (f2) must be related to the adherence of Robert de Bonnay to this party (h4), while on the other, we must relate the attestation of the removal of Jean de Bourgogne's influence over the Royal Council (f1), to the dismissal (g1) of his agent (h3) Philibert de St Léger. To confirm the formula given in figure 9 in a more analytical manner, we can try to interpret the relationships between the information in figure 1 and figure 8, not from the standpoint of "causality", but from the point of view of the "transformations". It is now easy to see that we can establish the equivalences provided by the two transformations (expressed in figure 10) between the general underlying schema of the plane in figure 1 (which corresponds to the "premiss schema" of the hypothesis) and the underlying schemata of the planes in figure 8 (condition schemata).

```
t4) Search for verification that y took control
    of a monarchic or seigniorial organization
    ⟶ search for verification of the accession
    of x to a post which is directly appointed by
    this organization.
    on condition that : it is possible to find
    verification of x's allegiance to y.

t5) Search for verification that y lost control of
    a monarchic or seigniorial organization ⟶
    search for verification of the accession of x
    to a post directly appointed by this organ-
    ization.
    on condition that : it is possible to find
    c1) verification that z was deprived of the
    post given to x, c2) verification of z's
    allegiance to y.

                              Fig. 10
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In these transformations, the search model on the right always corresponds to the plane 1 in figure 1 ("premiss"), while in t4), the model on the left and the data to be checked correspond to planes f2) and h4) in figure 8, and in t5), to planes f1), g1) and h3). The intuitive division into two blocs (see figure 9) of the planes in figure 8 is thus verified : it is now possible to affirm that, from a set of plane schemata which may, a priori, constitute the condition part of a hypothesis, we can construct as many separate hypotheses as there are schemata blocs defined. These blocs have to be interpreted as the (possibly conditional) transformations, bringing into play these schemata and the "premiss" (which will obviously be the same for the different

hypotheses).

Therefore, finally, we have two hypotheses which are able to reply to the question on Robert de Bonnay's nomination. The first, derived from the transformation t4) and formally expressed in figure 11, corresponds in effect to the fourth hypothesis in figure 5 of the preceding chapter ; it is easy to verify that the two planes in figure 6 satisfy this hypothesis.

```
premiss : α

α) incep+BE-AFFECTED-BY SUBJ    x
                         OBJ     m
                         SOURCE  n
                         date1 : d1
                         date2 :

restrictions on the variables of the premiss
schemata :
   x = <vedette>
   m = <monarchic-post> | <seigniorial-post>
   n = king's-council   | lord's-council
condition : A ∧ B
   A) BE-AFFECTED-BY SUBJ       p(SPECIF y)
                     OBJ        x
                     bound1 : b1
                     bound2 : b2

   B) incep+lid+BE-AFFECTED-BY SUBJ   n
                              OBJ     y
                              bound1 : b3
                              bound2 : b4
restrictions on the variables of the condition
schemata :
   b1 < d1 < b2
   b3 < d1 = b4
   y = <vedette>
   x ≠ y
   p = <seigniorial-organization>
                     Fig. 11
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The second, derived from t5), can be formulated in natural language, as shown in figure 12.

```
... one is nominated for a (official) post
                    BECAUSE
one's predecessor was linked with a very import-
ant personage who has just lost power

                    Fig. 12
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The two transformations t4) and t5) will now, of course, become part of the general corpus of transformations.

Conforming to the notion of maximum exploitation of the historical documents which make up the RESEDA database, Monique Ornato and Joanna Pomian have, by using again the data in figures 1 and 8 and procedure that I have just illustrated, tried to construct rules for replying to the question "Why did Philibert de St Léger lose his post as bailli of Mâcon." It is easy to see how they arrived at the two hypotheses in figure 13, which are symmetrical with those previously discovered.

This may be extended further by using information not given in figure 8 on the circumstances of the nomination of Philibert de St Léger as bailli

of Macon (who was in power at that time, etc).

```
    ... One might lose one's (official) post
                    BECAUSE  (1)
    one was connected with a very important person
    who has just lost power.
                    BECAUSE  (2)
    one's successor is linked to a very important
    person who has just taken power.
```

Fig. 13

IV   CONCLUSION

No doubt everything that I have just set forth will seem rather ad hoc, and this impression will be even stronger due to the rhetorical artifice that I have, for reasons of clarity, adopted in my text, that is using the same data, both in the construction and exemplification phases. In reality, this extremely analytic construction procedure makes it possible for the system of hypotheses and transformations to attain a degree of complexity and subtlety which is sufficient to cover a very large number of possible inferences.

I will now add two observations. The first, which is implicit in everything that I have written (see for example the interpretation in "hypothesis mode" of the transformations in figure 10), concerns the fundamental identity of the hypotheses and transformations. Although used in two a priori very different functions, they have basically an analogous function, that of suggesting uses of new search models which may lead to information having an interesting logical relationship with those originally sought ; that is, to suggest intelligent "connections".

The second is that the analytic phase of construction described in this paper, must obviously be followed by a phase of synthesis which allows the regrouping of the inference rules by means of most general "abstraction levels". Here I will limit myself to stating that we have turned to a "metarule" type methodology, see Davis [19;20], in order to resolve these problems ; some details on our approach may be found in [16].

I will conclude by recalling that, even if certain elementary modules have been in use since 1976, the construction of the system in its complexity (noting that, unlike most other expert systems, RESEDA must maintain a real, permanent database) only began with the phase RESEDA/1 in 1978. Considerable work from the computational point of view has thus been accomplished in these last few years, on both the analytic and programming levels, see once again [15;16;21]. We expect the completion of a prototype system to arrive in the autumn of 1981.

V   REFERENCES

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