The computer as an aid to reasoning in archaeology: an application: the Petit-Chasseur necropolis (Sion, Switzerland)

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THE COMPUTER AS AN AID TO REASONING IN ARCHAEOLOGY

AN APPLICATION: THE PETIT-CHASSEUR NECROPOLIS
(SION, Switzerland)

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Can the computer be of assistance in reasoning procedures employed in archaeology? Over the last ten years or so a great many allegations and optimistic predictions have been made about how effectively computer techniques could solve the archaeologist's problems: now there is no denying that the results achieved are scarcely commensurate with the efforts deployed. Without wishing to throw cold water on this type of approach, which is certain to spread in the years to come, we shall try here to single out its merits and limitations in a specific operation started a little over ten years ago, the establishment of a data bank to facilitate the processing of information gathered during the excavation of a late neolithic dolmen tomb site in the Avenue du Petit-Chasseur, Sion (Switzerland). The detachment we are now able to observe towards this experiment, as it draws to a close, affords us a degree of objectivity (Gallay, 1973, 1976-1, 1977, 1978 and to be published).

We shall deal with three notions: the data bank, reasoning and computer assistance.

Data bank

We shall go into more detail on this subject later; for the moment it may suffice to say that a data bank is a corpus of items transcribed by means of a language (metalanguage) which has greater coherence than natural language. The physical medium used, in this instance, is a magnetic tape for use on a computer.

Reasoning

By reasoning we mean any logical-semantic and/or mathematical procedure whereby data (archaeological material, observations, etc) can be converted into results corresponding to the interpretation of those data. Gardin (1979) has shown that this process involves three stages: the compilation of data (Cc: compilatory construction), the arrangement of data into a coherent structure (Ct: typological construction), and the interpretation of the data in that structure (Ce: explanatory construction).

The reasoning process enables progress to be made from non-formalised observations to Cc, from Cc to Ct and lastly from Ct to Ce.

Computer assistance

From this point of view, the computer can be of some help to the archaeologist; it can never take his place. In this respect, we see two limitations:

1. While computer processing enables the discursive reasoning of the archaeologist to be controlled and focused, it cannot replace such reasoning or (at the present stage of archaeological experiments) generate new types of reasoning. Emphasis must accordingly be placed here on the overriding importance of logical problems and the secondary nature of the "machine".

2. The assistance provided by the computer mainly relates to the passage from Cc to Ct, that is to say procedures for the arrangement of data. The most important sphere, interpretation, lies outside its scope although work in the field of artificial intelligence is aimed in this direction.

We shall accordingly be concerned here mainly with compilation and arrangement.

1. The corpus: a site

The Petit-Chasseur necropolis contains a large central dolmen on a triangular base surrounded by nine further dolmens and cists. These monuments are mostly built from re-used anthropomorphic stelae. The period involved covers Late Neolithic (Saône-Rhône civilisation), Final Neolithic (Campaniform) and Early Bronze (Bocksberger, 1976 and 1978; Gallay, 1983). The site's features are as follows:

- relatively complex monuments, arranged into a burial ground including individual and group tombs;
- complex stratigraphy comprising over a hundred separate units enabling fine chronological distinctions to be made;
- the topographical arrangement of the structures can be interpreted either diachronically (history) or synchronically (function). This applies both to the visible structures, ie the various monuments, and to the latent structures identifiable by spatial analysis of movable items, ie human bones, funeral accoutrements, etc (Leroi-Gourhan, 1983);
- a relatively small amount of archaeological material comprising funeral accoutrements and objects deposited or abandoned in or close to the monuments.

Sion's most striking feature is the importance of chronological observations for reconstruction of the historical development and functioning of the burial ground.

2. Objectives of the study

The purpose of the work is to describe and differentiate between the history of the various monuments and/or the various historical periods represented on the site; description of the specific features of the various monuments should enable the function of the burial ground to be interpreted; description of the various periods should enable the history of occupation of the burial ground to be reconstructed and hence the transition from the Neolithic to the Bronze Age to be understood.

By using the computer, we intended:

- to make explicit the basis for arranging the data both spatially and chronologically;
- to test the coherence of that arrangement and the discriminating power of the features selected;
- to avoid internal contradictions within the structures arrived at.

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This requirement of coherence and explicitness in no way prejudges the validity of the model or models selected. Validation of the results in fact necessitates looking beyond the site data to new observations not made use of in the present construction.

3. The data bank

From the theoretical point of view, there are always three aspects to a data bank:

1. A corpus of materials comprising all the date to be used.

2. A representational metalanguage always including a number of lexical terms. These lexical elements may or may not be organised into paradigms (hierarchy and structuring of terms) and/or syntactically. This metalanguage, which is a documentary language (DL), is sometimes called code.

3. A physical medium for the recording of information, whether it be the traditional book, a simple card index file, special non-computerised files or computerised files.

The importance of data banks in archaeology is partly related to the particular nature of the observations. In the experimental sciences, the raw material of study (virus, rats, frogs) is continuously available; it is accordingly always possible to refer to it and to set up a new experiment. In archaeology, excavation destroys material which can never be come back to again; data recording is therefore of key importance (figure 1).

Such recording may be effected by means of three different types of language:

1. Natural language (NL), that is to say ordinary everyday language.

2. Scientific or scholarly language (SL), whose structure is very close to that of natural language but has large numbers of specific technical terms.

3. Documentary language (DL) initially developed in libraries and subsequently in extremely varied contexts for the purpose of facilitating the management of information.

All three types of language are used in science but their particular fields of application are not always the same.

It is important in this connection to dispel a misunderstanding often encountered in archaeology. The documentary languages used in many data corpuses by no means constitute scientific theories. These can in fact be expressed only in varying combinations of natural and scientific language. While the inter-relationship between DL and SL is obvious, it is wishful thinking to suppose, as it has been supposed in archaeology, that the compilation of a DL can automatically produce a scientific theory.

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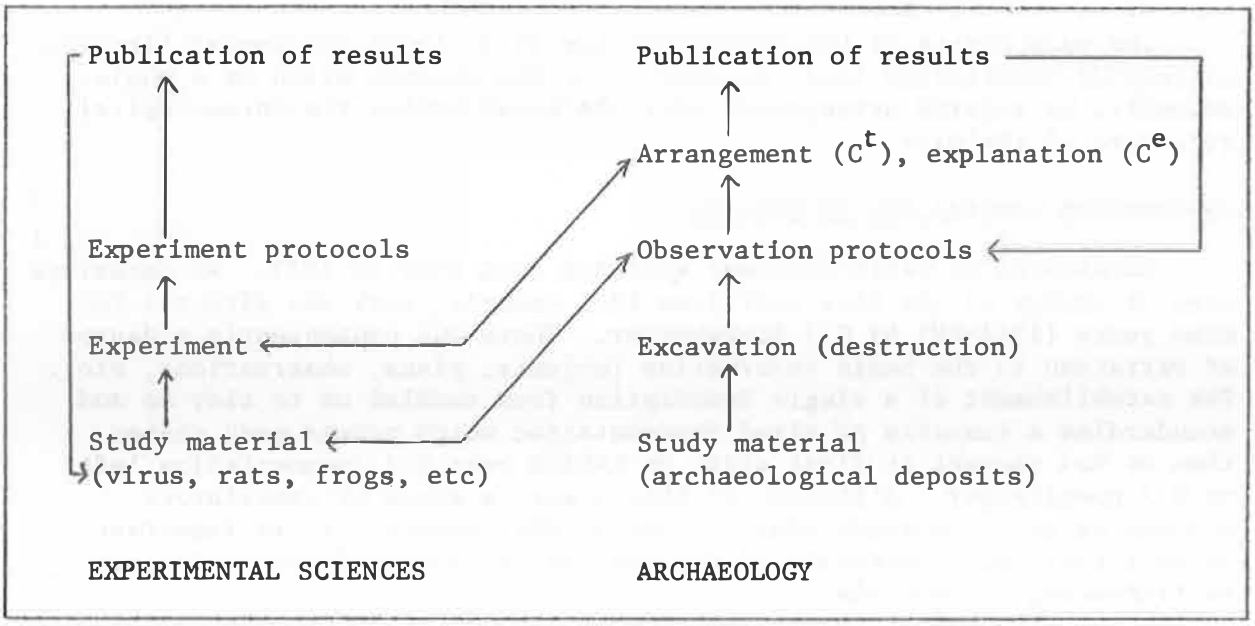

Figure 1 Course of research in experimental sciences and in archaeology. The feedback loops apply to the experiment's internal verification procedures.

It must accordingly be made clear here that the help which the computer can provide with reasoning problems is confined to the DL context, which constitutes a third limitation in addition to the first two already mentioned.

The data bank used for the Petit-Chasseur covers 1,838 recorded objects, viz 1,331 manufactured objects, 437 human bones and 70 animal bones. These figures include all the manufactured objects and a sample of the human bones comprising skull remains, teeth and scattered bones capable of defining spatial relationships. Only a very small number of animal bones implying spatial connections have been recorded.

The corpus is relatively small but a particular effort has been made in the qualitative description of each item, the recording protocol comprising 91 descriptive items:

- 26 items using NL, ie a non-controlled language (alpha-numerical notation),

- 65 items using a coded DL (54 items) or numerical DL (11 items) with a simple paradigmatic and syntagmatic organisation.

An important point to be borne in mind when evaluating the experiment is that the recording of information, which we did entirely ourselves, was spread over some ten years. The evolution of our own thinking accordingly interfered with the relatively rigid structure of the information collected, despite the relative flexibility of the computer.

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4. The merits of the experiment

The main merits of the experiment lay in at least two areas: firstly, as regards compilation (Cc), in control of the documentation as a whole; secondly, as regards arrangement (Ct), in establishing the chronological structure of the site.

Information control and formatting

Excavation at Petit-Chasseur extended from 1961 to 1973. We ourselves were in charge of the site only from 1971 onwards; work was directed for nine years (1961-69) by O J Bocksberger. There was consequently a degree of variation in the basic information (objects, plans, observations, etc). The establishment of a single description form enabled us to tidy up and standardise a quantity of mixed documentation which proved much richer than we had thought at first sight on taking over the documentation left by O J Bocksberger. Although, at this stage, a sense of compilatory purpose is more important than the use of the computer, it is important to note that the constraints of the machine certainly played their part in tightening up analysis.

Chronological arrangement

The burial ground comprises over a hundred stratigraphical units, ten monuments mostly presenting several phases of construction, use and degradation (cf Gallay to be published) and a number of individual tombs from different periods in the site's history.

The data bank was used to begin with to gradually compile an outline chronological arrangement including both the monuments and materials found in primary position and the elements modified during the utilisation, modification and plundering phases. During this phase, DL—SL interaction remained constant and of the highest importance.

Chronological arrangement is based on concordance between the assignment of items according to three criteria, viz stratigraphy, typology of material and modes of deposit.

Stratigraphical assignment. The use of the sequence of layers has proved sufficient, as the position of monuments in relation to this sequence can be handled without a computer.

Typological assignment. This is based both on external knowledge and, in the case of Early Bronze, on the stratigraphy found in one of the dolmens (MXI). It comprises six distinct classes:

1. Late Neolithic (Saône-Rhône civilisation),
2. Final Neolithic (Campaniform civilisation),
3. Early Bronze I
4. Early Bronze II
5. Early Bronze III/IV
6. Early Bronze IV

(items 3–6: Rhône civilisation)

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The objects discovered are assigned to one of these six classes or a combination of several (eg Early Bronze II/IV) according to their intrinsic properties alone, without taking their stratigraphical positions into account.

Assignment by mode of deposit. This parameter implies detailed analysis of the disposition of objects in the soil (latent structures, cf Leroi-Gourhan and Brézillon 1972, Leroi-Gourhan 1983); it accounts for the positioning of movable items (Gallay, Chaix, Menk, 1974). The main distinctions are as follows:

- INCERT - mode of deposit unspecified
- REMAN - modified by natural agencies (burrowing animals, rainwater run-off)
- HUM - human intervention
  - ABAND - abandoned with no apparent order, lost
  - JETE - removed from monuments and thrown away outside (plundering layer)
  - DEPOT - deliberately placed in a particular spot, grouped items, etc
  - BOULV - disturbed and modified on the spot
  - RECOUP - modified in a layer traversing older levels (pits, trenches, superficial layers modifying a subjacent level).

It is then possible to validate the coherence of information contained in a data bank by means of simple sorting procedures according to the following formula:

Printing criterion (OBJECT ... TYPOLOGICAL DATING)

Sorting criterion (LAYER ... TYPE OF DEPOSIT)

OBJECT	LAYER	TYPE OF DEPOSIT	TYPOLOGICAL DATING
489	5A53	JETE	FINAL NEOLITHIC CAMPANIFORM
590	5A53	DEPOT	EARLY BRONZE I

Subsequently it was possible to test the whole of the construction in its final form (fig. 2).

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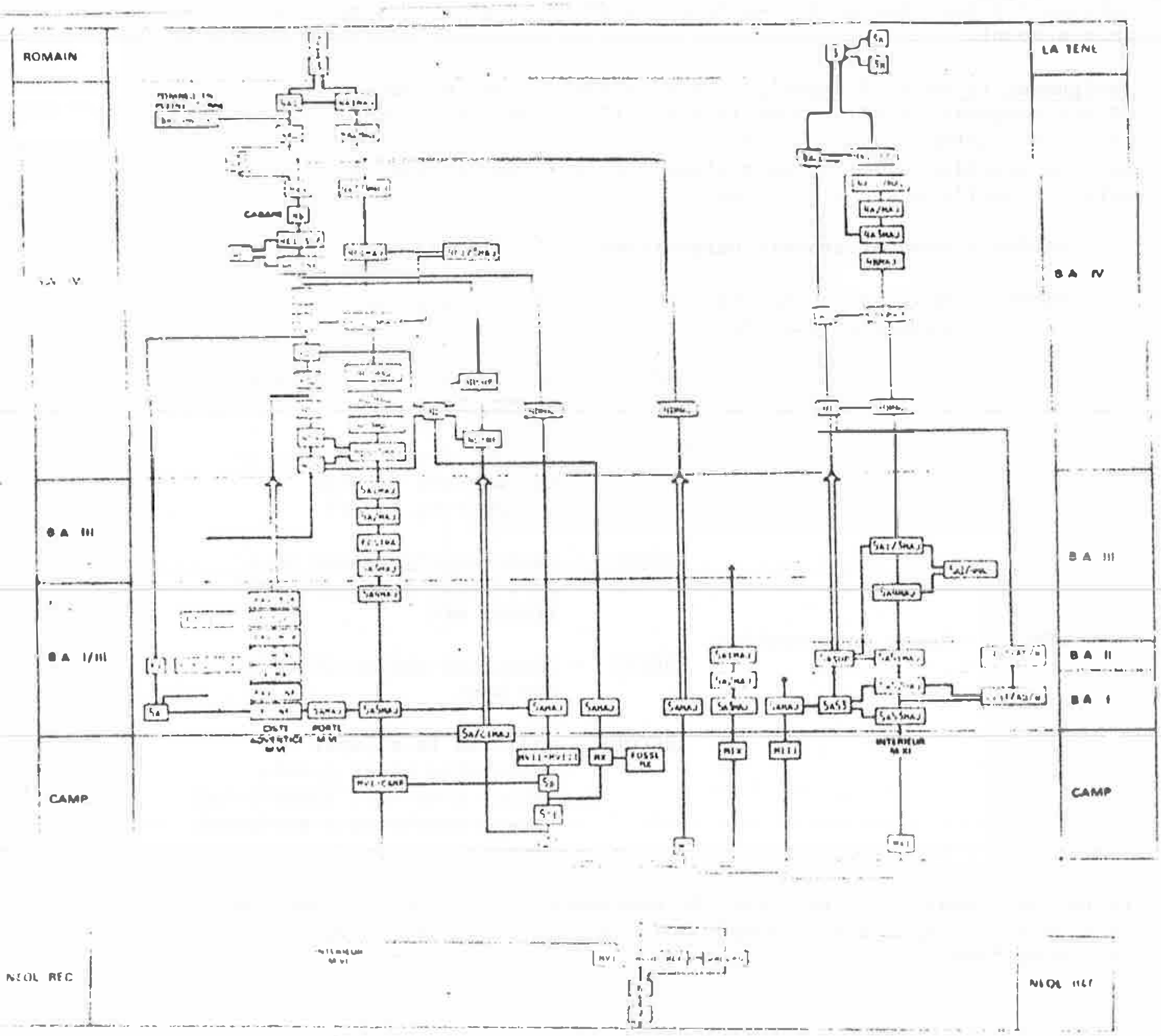

Figure 2 Arrangement of the chronological sequence

The concordances between the three parameters, established on the basis of empirical knowledge of the site are summarised in table 1. For each of the nine historical phases on the site there are corresponding precise associations of aechaeological materials defined both by their chronological allocation and their mode of deposit. The computer is able to handle the whole of the data very quickly and to check the various associations.

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If we return to the previous example, which raises the question of how to assign layer 5A53 surrounding dolmen MXI from Early Bronze I, the basic hypothesis may be formulated as follows:

Layer 5A53 - material CAMP - position JETE, and

Layer 5A43 - material Early Bronze I - position DEPOT.

We assume therefore that this layer includes primary deposits of materials from Early Bronze I and a layer of pillaging (JETE) including Campaniform materials in secondary position.

Of the 136 objects found in this stratigraphical unit, 79 confirm strictly to the above pattern, 47 are in a neutral position and ten contradict it. The presence of a few typologically too recent shards can be explained by difficulties in layer assignment during excavations.

If we generalise from these remarks and base our calculations on the significant data set out in table 1, we obtain the following results:

1.	number of manufactured objects in the catalogue:	1331
2.	number of objects in stratigraphy:	1237
3.	number of objections with typological peculiarities that may be interpreted in terms of the chronological assignment selected:	1210

Among the latter:

1.	objects confirming the construction:	495 (40.94%)
2.	neutral objects:	660 (54.55%)
3.	objects disproving the construction:	55 (4.55%)

The degree of probability that the chronological sequence of the site conforms to the pattern suggested as a hypothesis is therefore 95.49%.

5. Limitations of the experiment

The main limitations of this experiment lie in two areas, firstly in over-information, secondly in the difficulties in up-dating data.

Over-information

On looking back with hindsight on the quantity of information that we wished to record in the data bank to begin with and the amount used for our construction, we find that we actually used much less.

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In trying to assess this reduction, we may classify the descriptive items provided for in the original recording protocol into four categories:

Category O. Items for which we have never recorded information, mainly owing to lack of time.

Category C. Items which we gave up recording in the course of the experiment.

Category B. Items for which we completed recording - because we think they are important items of information for the compilation of a catalogue of objects from the site - but which have not been used at the present state of research in producing the construction. These are compilatory information (c) only loosely connected with the construction.

Category A. Items actually used in the research into the chronological arrangement of materials. Categories A and B together enable a catalogue of site materials to be produced including, we think, the most important of the observations made during excavation. The situation is summarised in table 2.

We see that only 14.3% of the information provided for at the beginning was actually used in connection with the computer.

Let is be said, however, that this discrepancy between theoretical design and practical use was not due to the irrelevance of the items which were neglected or abandoned, but to the fact that the computer was not useful at this level. Let us give two examples:

Chronological relationship between objects and monuments. We had initially planned a relatively complex descriptive system for specifying the stratigraphical relationship between objects and monuments (visible structures) and for deducing a chronological relationship (items 65-78).

For any particular object this relationship was expressed in a coded form of the following type:

65	*66*	*67*	*68*	*69*	*70*	*71*	*72*
DANS	X	X	COUCHE	5B	ANT	X	X
HORS	MURET	INCLU	CISTE	6	CONT	OU	POST
SOUS	X	X	COUCHE	5A	ANT	X	X
SUR	X	X	COUCHE	5C	POST	X	X
SOUS	DALLE CAL	OUEST	CISTE	7	ANT	X	X

We fairly soon dropped this type of information because we realised that the simple object-layer relationship (stratigraphical assignment item 56) was necessary and sufficient for our construction and that we did not need the computer to handle layer-monument relationships.

Latent structures. We had originally intended to use the computer to study the distribution of objects on the site and to deduce latent structures. However, recording the information necessary for this purpose implied previously plotting the data.

Since the main work thus had to be done manually, use of the computer became irrelevant.

In either case, therefore, use of the computer was not necessary; it was of no help to us, since we were able to handle the information by other means.

Up-dating limitations

Another stumbling block was the problem of flexibility in up-dating the data bank, ie in matching the information collected to the theories worked out (DL-SL matching). Advocates of data banks in archaeology have often acted as if a data bank could itself generate its own up-dating as a result of the pressure exerted by theories. It is clear that the course of events which we describe in the upper part of figure 3 is impossible in practice because it can result only in degradation of the information contained in the original corpus (by suppression or combination) but certainly not any enrichment (by dissocation or addition). This situation, which ought to be well known, entails always going back to the empirical facts in their totality, which obviously restricts the speed and effectiveness of up-dating and hence the flexibility of the instrument.

UTOPIA

Empirical facts

Data banks
(documentary language DL)

Theories
(scientific language SL)

REALITY

Empirical facts

Data banks
(documentary language DL)

Theories
(scientific language SL)

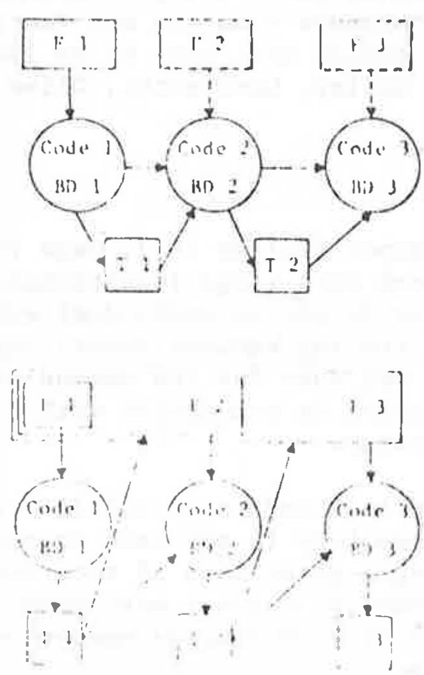

Figure 3 SL-DL interaction and data bank up-dating

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Let us give two examples of this state of affairs:

Typological assignment of Early Bronze ceramics. The descriptive code originally distinguished simply between Old Early Bronze and Late Early Bronze. It was only after exploiting data from the MXI dolmen (Gallay, 1982) that we realise the usefulness of a division into four phases. We consequently had to reconsider all the Early Bronze materials to generate a new type of information which was recorded under an alpha-numerical item in NL (item 19) with all the difficulties involved in using a non-controlled language.

Typological assignment of Campaniform ceramics. The problem raised by the assignment of Campaniform ceramics is exactly the opposite. The typology proposed initially was based on the historical hypotheses of Sangmeister (1963). We had then distinguished between the following classes:

1. Eastern Campaniform (phases I, II and III)

2. Atlantic or Western Campaniform

3. Rhineland Campaniform

4. Mixed Campaniform related to the reflux horizon

5. Italian Campaniform.

This system unfortunately proved inadequate to account for the various Campaniform ceramics on the site and had to be abandoned. Owing to the difficulties encountered in this respect (Gallay 1976-2) we ended up by temporarily giving up making any kind of distinction within this type of ceramics and put all the variants into one and the same class. Since then, new theories have been put forward, eg under the influence of research in the Netherlands (Lanting and Van der Waals, 1976; Gallay, 1979). Consequently this question will have to be looked at again in future from a new angle (see eg Gallay, Carazzetti, Olive 1983). Our data bank will then be of no use.

6. Assessment

In a previous paper (Gallay 1977, page 103) we wondered whether it was profitable to work with large institionalised data banks able to deal with several sites or to set up individual experiments involving more frequent to-ing and fro-ing between theory and practical fact. Our personal preference was then for the second alternative. We thought that the experiment conducted in connection with the Petit-Chasseur corresponded to this type of strategy.

We would now be inclined to go still further in that direction. Current developments in archaeology in any case do not permit large-scale scientific experiments involving a great mass of recorded information. It is accordingly appropriate to conduct more experiments in machine processing in very limited sectors of even more modest ambitions than the Petit-Chasseur project.

This situation is due to the fact that archaeology is at present not a fully fledged science. Before embarking upon vast computerised programmes we need first of all to define the logical bases of our discipline. A great deal remains to be done in this area. It would be mistaken to try and link the requirements of computer processing with the as yet still highly impressionist style of discourse (Gardin et alii) of the so-called human sciences.

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	Items			Totals	%	Cumulative %
	Numerical NUM	Coded DL	Non-coded NL			
Totals	11 (12.1%)	54 (59.3%)	26 (28.6%)	91	100	
Category O	3	20	2	25	27.5	CBA 100%
Category C	1	15	14	30	32.9	CBA 72.5%
Category B	4	13	6	23	25.3	BA 39.6%
Category A	3	6	4	13	14.3	A 14.3%

Table 2 Items recorded in Petit-Chasseur data bank. See text for explanation of Categories A, B, C and O.