International Review of Social Sciences and Humanities
Vol. 2, No. 1 (2011), pp. 49-67
www.irssh.com
ISSN 2248-9010 (Online), ISSN 2250-0715 (Print)

Thinking the Past Anew: The Prehistory of Non-Linear Digital Systems in Archaeology: 1960-1990

G.V. Loewen
Tenured Professor and Chair
Department of Sociology, STM College
The University of Saskatchewan
1437 College Drive, Saskatoon, SK
S7N 0W6 Canada
e-mail: gloewen@stmcollege.ca

(Received: 30-7-11 / Accepted: 7-9-11)

Abstract

The current state of digital technology and its associative or synaptic templates in archaeology has its own prehistory. The thirty years leading up to 1990 saw the developments crucial to technological advance in the processing and analyzing of archaeological sites and data. Yet it also saw a shift in mind-set regarding what constituted data in archaeology, and the genesis of the so-called 'new archaeology' often associated with Ian Hodder and others. It is here argued that such a shift would not have been possible had it not been for contemporary and corresponding shifts inn the architecture of computer platforms and soft-ware that began to se their first application in archaeology and related academic disciplines.

Keywords: archaeology, computers, associative systems, non-linear logic

Introduction:

1. The logic of "Non-Linearity" and its Implications for Archaeological data Collection and Recording

The current state of digital technology and its associative or synaptic templates in archaeology has its own prehistory. The thirty years leading up to 1990 saw the developments crucial to technological advance in the processing and analyzing of archaeological sites and data. Yet it also saw a shift in mind-set regarding what constituted data in archaeology, and the genesis of the so-called 'new archaeology' often associated with Ian Hodder and others. It is here argued that such a shift would not have been possible had it not been for contemporary and corresponding shifts inn the architecture of computer platforms and soft-ware that began to se their first application in archaeology and related academic disciplines.
To that time, most computer systems having academic application have concentrated on reducing observation linearly. "Linearity" in this sense is metaphoric. "Linearity" defines a pattern of relations that exists amongst texts. "Linear links" are patterns that do not use expressly associative or analogic relations. Texts are ordered in a deductive and strictly logical manner. Logic in this sense would include chronological or numerical ordering. Observation is translated into a model, through a method of simplification that uses linear linkages. Linear links postulate a simplified world *via* the application of various forms of logic. In archaeology, analysis often involves the translation of descriptive data

concerning objects of both cultural and natural deposition into usable interpretative classes. Some attempt at explanation can begin (Dunnell 1986). The effectiveness of such methods is not to be questioned here.

Wittgenstein's "parable of the rope" will help explain. Knowledge is like a rope. Its many strands are constantly re-woven into a form that makes up the rope as a whole. The rope represents all human knowledge. However, the states of knowledge and the intermingling of the strands within a rope change. Therefore, at any one moment, all human knowledge cannot be realized. The strands are linked in a manner dependent upon one another for meaning and function. It is the links that exist among states of knowledge that constitute knowledge itself, just as the strands make up the rope in the parable. Humans, as the possessors of such knowledge, exist within the rope. Hence, all knowledge can never be known.

The assumed impartiality of the scientific investigator is an attempt to understand merely one state of knowledge. The point of Wittgenstein's story is to place the investigation in the sum of knowledge. Placing the investigation here allows linkages to be made amongst the strands, that will not rest on the linearity of logical operations. A linear logic provides the investigators only part of what they seek, i.e. a constructed linearity of events leading to other events through a notion of antecedent and cause.

The construction of the remainder of such an analysis was accomplished through the use of a "non-standard" system of logic. Metaphoric analogy and connection *via* association were the two most important features of this system. With the use of analogy and association, the strands of knowledge were understood in their full meaning, and not merely their logical order.

The addition of an alternative system of logical thought had relevance when applied in a computer program. Technology of that period enabled the investigator to analogize and associate while receiving full cooperation from the new software. All that was necessary, besides the specialized knowledge of the archaeologist, was associative thinking, and the ability to link disparate events by metaphoric analogy. Analogic thought processes are assumed to be universal for any potential program user. Analogy and metaphor have contributed to archaeological analyses in the past (Wylie 1985), and such facets of thought occur constantly in the mind. Although there may be other forms of thought that do not have relevance to the basic patterns of analogy and association, it is difficult to think of what they might entail.

By 1990, there appeared a technique that would use to their fullest extent such assumed fundamentals of human thought. Students did not have to suppress any particular method of analysis that could be labelled analogical or illogical, simply because it does not follow a linear form. Science as a whole benefited when it included any new system of relations that helps it attain its goals. Any suppression of relevant thoughts would have been detrimental, just as the failure to include relevant data is judged harmful to a particular scientific interpretation.

Archaeology often used statistical correlation and pure description as replacement for the causal explanation of the physical sciences. It would thus benefit from an additional system of relations. Since archaeology seemed at the time less constrained by the formalism of scientific rigor than many other disciplines, it was perhaps an ideal area for such an experiment in digital media. These experiments demonstrated the logic of non-linearity.

If a "medium is the message", then an non-linear system had many messages at once, because of its use of "associative links". The concept of a system of such links related to scientific analysis was first envisioned by Vannevar Bush, who was F.D. Roosevelt's scientific advisor (Ambron and Hooper 1989). In 1945, the article "As We May Think" appeared in "*The Atlantic Monthly*". It outlined the concepts that were decades later were to resurface in associative system (Ambron and Hooper 1989:89). The article said that computer tools could be designed to mimic the way in which human thought processes were understood. The computer software should use the human mind as an analogue, to mimic this perceptual process *via* analogy, thereby becoming an aspect of human "self-reflexivity" (Ambron and Hooper 1989:91).

The first working application of such a system took place in 1987, with the advent of the Apple Corporation's software program "Hypercard", by Bill Atkinson. Digital non-linear programs used the associative process in human thought patterning to link a variety of data, in a variety of disparate media. There had been other and earlier guises of associative system in the form of "hypertext" programs, but the Apple non-linear program was the only application with almost unlimited use during the period in question. The inherent system of logic within which such a digital non-linear programs functioned, and any technical considerations, were unique to that program. The only design limits voiced by its creator were the limitations of the user's and programmer's imaginations. A custom design of the associative system program could include the considerations of an archaeological analysis. The problems that archaeology encountered were to be addressed dynamically.

Technology is often seen as a panacea for the problems of the world in general, and academic venture in particular. A technological panacea is an illusory notion, as technology ultimately derives its usefulness from the creativity and wisdom of its creators and users. Technology cannot be divorced from its humanity, or from the problems that are to be solved. The lack of such a humanity causes many of the characteristic conflicts between uses of technology. Although seemingly benign in its applications, this variant on the technological theme was be treated as any other; with as much circumspection as is deemed necessary to get the job done. However, the means existed within associative system technology to pursue many more goals dealing with interpretation and data representation, or even site collection and recording techniques, than were previously possible. A feedback is created by the qualities of a multi-media application. With compatibility, communication between computer systems is entailed. More importantly, compatibility entails relevance to human understanding, and to archaeology.

Data collection procedures in archaeology seemed suitable for use in a associative system. The associative layers of digital non-linear programs were akin to layers in an archaeological site. We can carry the analogy farther, as non-linear programs allows data presentation in numerous ways, possibly as numerous as the association amongst data in the *in situ* context. One hoped to recreate the site within the computer as it was excavated.

Coupled with a program that turned any video recorder into a scanner, scanning images into the system as graphic text, non-linear programs could then present current accounts of any process to do with excavation. Non-linear programs were transformed into a monitoring system, in which data could be entered as soon as they were unearthed. Such an opportunity for investigators in the field was deemed positive, as it allowed several steps, with all their inherent biases and potential for error, to be skipped in favor of a single operation. The artifact was identified by its scanned image. A field monitor, linked to a video recorder (as scanner), would also allow for appropriate statistical operations to be performed immediately, as new data were entered. A running count of not only the visuals of an investigation, but also the statistical and interpretive series was kept within a field-based associative system. Investigators would have a time-lapsed record of all their work, to be reviewed in the light of further investigation and information. Whole sites were to be transferred from lab to lab, facilitating greater comparative study. Greater reference capabilities that included more detailed analyses, as well as more complete data bases were suddenly a possibility. Detailed databases were something that both archaeology and ethnology could not then provide, for example, when students publish statistical conclusions in their respective journals.

A comparative collection could also be entered previous to a season's work, to provide a basis for on site analysis of faunal and artifactual remains. Photographic images that once acted as a supplement to excavation, as well as artist's line drawings, were now no longer necessary in order to maintain a precise record of the investigation. The system, however, remained compatible with previous excavations, as all past graphics and text were easily transferred into the new system. Record keeping within site collection procedures should be made more precise, because of the smaller amount of steps and the accompanying reduction in elapsed time between discovery and interpretation.

Contexts of sampling were also defined differently. The most relevant method was no longer purely up to the investigators, who may have found it difficult to remember all the details of the many studies that were at their disposal. The previously collated details were already within the system, and a variety of sampling procedures could be run in the system that ultimately allowed investigators to choose which was most relevant for a given problem.

The implications in the practical realm of technological capability were not as important as other pragmatic implications that occurred in the realm of changing research designed to exploit, not to fit the limitations of the technology. The investigator could push back the frontiers of archaeological research design by employing an associative system. The practical implications that stemmed from new possibilities involved rather the interpretive realm. An initial loss of standardization of archaeological technique and analysis did in fact occur. However, non-linear programs could be "locked", in the sense that other users cannot enter and change a data base, or rewrite the interpretation. Digital non-linear programs could be used as both a "read-only" and a "write-read" system.

The idea of "hypertext" was coined in the early 1960s by Theodor Nelson. The construction of such a system would involve the creation of interactive links within a large body of textually related material. "Interactive" would mean a "write-to" scenario, where users amend and add to the database, and follow paths through the "archive" without the loss of original context. By "archive", it was meant the entire body of texts that archaeology has at its disposal. Associative systems were an extension of the concept of interactive texts, and allowed the incorporation of graphics, sound, and visual communication with other users, in addition to the textual aspect.

The methods included a systems hierarchy, a systemic flow chart, a non-linear array of interlocking data sets, and a combination of all these. The hierarchy would have been already familiar, as it echoed a pyramid-like structure of other applications. The flow chart was familiar from the literature of cultural ecology, an anthropological perspective that used schematic diagrams to portray environmental systems. The non-linear associative structure was the most complex, and the most interesting. It rested on the user's ability to make associative connections within a group of data. Archaeologically, either associations suggested to the user from the data 'itself' or some that are more intuitive were implied.

The programmed links in a associative system application differed from previous types of data base links because the new links were fluid in their design, and could be changed by the user. No obstacle was presented if the user's idea of what is associatable was different from the author's. The system had other less direct pathways for the users to reach their goal. Such types of linked inventory transformed lists of artifacts into comparative collections. Links increased each assemblage's relevance to archaeologists working with related material. Assemblages then existed in the realm of constant test and comparison, complete with graphics and description. Critical commentary throughout the system's levels became available, and the creation of so-called expert systems, with the contributions of many archaeologists, was now for the first time possible.

2. The Development of Associative Logic Programs in Archaeology

Since its invention, the computer had always held out much promise to science for data organization and economy of access and use. Many applications had then been designed, addressing diverse angles in academic disciplines, business, and education. This section reviews some of the typical linear media applications in archaeology, and juxtaposes them with typical associative system applications from a variety of disciplines then in current use The relationship between previous cases involved in the genealogy of associative non-linear systems and a general concept of an associative system itself will be identified. The major difference was found to be that the previous pre-associative system programs were numerous and relatively well documented in archaeology, while literature for what was during this period new associative system object-oriented applications was either non-existent or poorly documented.

During the three decades prior to the completion of the basic non-linear programming analytics, the entire field of associative system research was nascent, but in the field of education in particular, whether the actual designed programs address English literature or the history of molecular physics, associative system applications represented the cutting edge of computer research tools. Such an incipient movement in the computer world would, in fits and starts, be exploited thoroughly, and eventually brought the power and creativity of associative systems into such academic disciplines as archaeology.

Most linear applications in archaeology attempted to quantify data in either a non-manual manner, or mimic a manual process at a much faster pace. Most used tables of information as a presentation medium. The table occupied a screen, and was static. It consisted of what could be duplicated on a sheet of paper. One had nowhere to go from the location of the table but to the next "page", in a linear fashion. Tables were employed in the presentation of statistics (Doran and Hodson 1975:93), or seriation, maps, scatter-grams, histograms, and other plots (Doran and Hodson 1975:111-115). What such displays had in common is their theme of design. During the 1970s, archaeology moved from borrowing applications from computer science to the creation of its own networks. Most construction of archaeological programs was accomplished by *ad hoc* copying and experimentation. A number of examples can illustrate the earliest phase in archaeological computing.

The ORACLE project was a site data base typical of the kind of networks it spawned. Running from 1977, and including more than 4000 site records, ORACLE used pseudo-associative system links via a DOS based system to link information nets together for retrieval (Cook and Limp 1981). The problems encountered with such a massive database were defined as archaeological variables. The manipulation of large numbers of variables, such as biostratigraphic sequences, site features such as a terrace, and other biophysical matrices was important. Records of each feature were kept linked to that feature by a set of user commands. Requesting information here was similar to the use of an IBM optical ROM drive, although that technology was not available at the time of ORACLE. Command sequences are initiated by the user, and information appears. The era of archaeologist as computer scientist or programming expert had begun around 1975, and ORACLE was an early example of the potential for such personal interaction.

The ORACLE application was particularly interesting because it was one of the first of its kind to employ a multilinear hierarchy of paths toward sets of related information. Such a network of paths was linear, and associative only in the proscribed sense of the program's limitations. However, more access to the data set was created than that found in previous "flat" networks, where data were presented within a regimented schematic.

The Arizona State Museum site inventory project could be seen in similar light (Rieger 1981). On line in 1970 and modified extensively in 1980, it provided once again a massive listing of not only sites, but of "componential fields" within sites. With 31 "first level" fields and 37 "second level" fields the amount of cross referencing of information was impressive. The AZSITE program was the largest of its kind in Arizona, and is typical of the decidedly linear operation of archaeological database structure.

The SARG or Southwestern Anthropological Research Group project was similar in design and function to the still popular statistics package SPSS (Plog 1981). It was first set up in 1972, and used a dictionary cross reference interface between user and data. It served as an example of different kind of access route taken by the user to arrive at a data set. The addressing of certain archaeological problems of method and theory was attempted. The choice between a numerical access codes for acquisition and storage of information or the so-called "free text" method (Plog 1981) had not yet been made in its final form. It involved a dialogue between the linear and the multilinear, but the former sacrifice descriptive detail just as the latter lose out in comparability.

An attempt to deal with large archives of archaeologically related material from a wide range of interfaces was made with SOFIA, or "inversion of file access operating system" (Le Maitre 1981). SOFIA was designed in 1977 and was in use at the archaeological research centre (C.N.R.S.) at Paris. SOFIA was one of the first programs to interlink modules of information by multihierarchical ties. The operation of the system foreshadowed the "object oriented programming" of end of period applications, but mimicked the discrete packages of information on the user level of information access. Two types of relations were set up in the system, and one could approach the two from various routes. An entity had a set of expressions that defined its modularity as in a description of an artifact via statistics of length and width, etc. and many groups were linked by expressions that existed amongst modules. Each entity might be an archaeological item; an artifact or a feature, for example, or they might be whole sites, historical documents, geographical regions or paleocores.

While the effort at linking discrete objects at the user level had been mimicked within contemporary computer languages, the idea of location of the user's language was addressed with the application SATIN 1 (Bourelli and Chouraqui 1981). SATIN 1 focused on the dualities and ironies that existed between the level of language parameters, whether natural or computer, indexing or dating, and the level of representation. Since many archaeologists did not work from the artifacts themselves, but merely some type of description of them, ambiguities extant in the linguistic expression of such a descriptive language carried over into the realm of representation.

The SATIN 1 program was of interest for the following reason: How did one manipulate a computer language to compensate for linguistic ambiguity on the user level? The goal of the designer was consistency of information. Rules of semantics and syntax were effectively included within a program to produce an "indexing language of objects", in order to describe an object objectively.

The largest multilinear application in Europe consisted then of the data base FRANCIS, communicated via the EURONET telecommunications network. The system stored a massive amount of information culled from sources in many languages from the world over, and could access any journal article or abstract, as well as historical documents covering the prehistoric period in Europe to 1939 (Martlew 1984:108-9). While only French prehistory was at the time completely covered, over 450 archaeological journals were consulted in inclusion, and over 200 other periodicals. The references for the links between hardcopy document and the system as a whole were treated as keywords. Each document's abstract contained between one and 42 keywords. When keywords are called upon, they linked the user with other sources exhibiting the same keywords. The cross referencing was as extended or truncated as the amount of keywords encountered by the user.

Finally, one of the original packages that allowed the user the creation of graphics and facilitated links between graphics and other types of information in one system was PLUTARCH (Wilcock 1974:64). A photosensitive light pen was employed in the drawing of graphics.

So far, we have cursorily discussed some examples of period typical archaeological computing systems. The typical systems dealt with the inclusion of already created text files, and graphics. We now move from particular case studies involving archaeological computing, to more general issues involving all such attempts. However, general issues are also explored by examples from various case studies that directly or indirectly have had an influence on the development of non-linear digital media in archaeological data analysis.

The idea of what computer enthusiasts, archaeologists or not, might be creating in their attempts to store, quantify, and access any discipline's information was addressed in a set of essays in Cooper and Richards (1985:5-13 *et passim*). The "archive" was defined as that which was self-created by interaction of user/author and text. The forefront in archaeological computing had shifted focus from what the text should include. Although "what the text is" may still be an epistemological or even an hermeneutic concern today, the question of how one should go about accessing archival information, or "interrogating the archive" via various types of distinct software had gained a certain prominence (Cooper and Richards 1985:9).

The first time that levels of enquiry and hierarchies of archaeological data were discussed in the specific context of computer applications was important for this application. The artifact and artifact group levels were defined, as well as features, patterning of groups, and area levels of archival information. Cooper and Richards (1985) discussed the predecessors to possible non-linear organizations in operating systems. Types of interrogatives could be arranged in a pseudo-object oriented hierarchy, from the detailed close-up of a single artifact, to more global foci like topography or ethnic migrations and their relation to discarded sequences of material culture. The system that was detailed used the long archaic programming languages dBase II and III. The dBase software continued to upgrade itself and general users were currently acquainting themselves with dBase IV. The authors concluded that the material available to archaeology would continue to outstrip the pace of computer technologies available to cope with its mass.

Carver (1985:47-62), in the same volume, attempted to address the issue of too much material by proposing that the computerization of the archive could be a motive for creative archaeological work. By the mid-eighties in archaeological computing, the idea of the machine as a useful tool in the service of archaeology was replaced. Instead, the computer presented a new language in which archaeologists may think about their work.

Although authors varied on how they saw the trend of computing affecting their discipline, many agreed on some pragmatic aspects. An early example of what effect computerization and/or standardization of some sort might have had on field archaeology was important, as it extended its potential into the field. The future development of both method and theory *vis-a-vis* the archaeologist in the field and the interpreter in the lab, even if they existed within a single being, had to then be addressed (Rielly 1985). The origin of all archaeological inference and record lay in the field, and indeed the field remains the place where all primary discovery is made. The distance between the raw data of observational excavation and the archive of archaeological knowledge could obviously be great, and methods to narrow such a gap had to be found.

If most archaeological data is descriptive, consisting of found attributes, then description at some point during the research process must give way to manufactured or inferential data. Much published archaeological information a the time consisted of interpretation and analysis, rather than original description. Rielly (1985) describes several transformations that had important implications for any inference to which the archaeologist wished to commit. The process of refining and redefining data as it comes out of the ground, is still a process of changing the idea of what data is. Data move towards the lab, and are entered either on a computer database or some other recording device. Whether or not data are evidence depends on one's argument, and often data from the same site are used in contrary documentation and argument. Such data, if seen at the level of site context, may not prove contrary. The ideas of "site as location of argument" *versus* "inference as a location for an argumentative language" could not be outlined by the reduction of detail to generality, from the particular to the comparative (Rielly 1985). Data were, and are, constantly reworked, and the location from which the investigator created and observed data is always moving to a unique position, never to return to exactly that previous.

By 1987, Wilcock and Biek joined others for an international conference on science and archaeology in Glasgow. Out of that conference came two relevant articles (Biek 1987:541-3; Wilcock 1987:497-507). The first was an attempt at a summary and a pulling together of directions in archaeological computing, the first of its kind by an archaeologist. Wilcock wanted to create a cohesive body of texts to outline where the discipline had moved, and where it was likely to move in the future. Knowledge of past and present computer trends within archaeology was lacking. Computers had been used in archaeology for over three decades, but their employment was diverse and purpose disparate. For example, statistical analyses were first performed by computer in archaeology in 1963, while site records were entered into a machine as early as 1959, and geophysical variables collated and organized by computer in 1968 (Wilcock 1987:498).

Developments in the areas of archaeological computing were necessarily tied to advances in technology. If such developmental advances were to be recognized by archaeologists, one must assume that applications, if they were to serve a serious purpose in a proposed area, must be designed at least in part by the then growing body of archaeologists who were also computer scientists. A group of computer experts could not become a clique, but rather should be a body of consultants, to be consulted as well as consulting other students in areas of need. A creative process could result, if one allowed for the then often disorganized and non-standardized situation of computer archaeology to continue, while trying to lessen the impact of redundant innovation. Coping with redundancy could then only be accomplished by published communication *via* journal articles and reports on symposia (Wilcock 1987:501). Problems that were important to focus on in the present included the unorganized attitudes towards research and the lack of funding for such research, but most importantly, the incompatibility of the many interesting and new programs then being developed, and the incompatibility of the hardware to run them on. Wilcock suggested that all archaeologists use the same machine and the same programs.

Biek's (1987:541) article outlined an alternative to Wilcock's solution. Here, one of the original versions of the laser ROM videodisk, DOMESDAY, was outlined. It had the then impressive storage capability of 100,000 graphic frames, and an acceptable speed of about two seconds per movement between frames. Conventional hardcopy reports in archaeology eventually would be made technically obsolete by videodisks.

One of the earliest mentions of interactive media and diagrams in archaeology was detailed by Ryan (Ryan 1988). The purpose of Ryan's interactive application was the analysis of stratigraphy, and the operating system was similar to standard graphical representations of extended kinship genealogies. "Gnet", as it was then called, allowed the user to create diagrams from previously stored information. There was no correct manner of construction for the stratigraphic diagrams included in Gnet. The program could also interact with other sources of data, linking a created diagram with variables that made up that graphic.

Nearing the end of the period in question, the possibility of the introduction of expert systems into the archaeological realm had also been addressed. Stutt, (1988), detailed some problems and prospects. How did one prevent such a system from becoming statically formalized, with its knowledge base regarded as complete, holding the correct answers for a finite set of questions that may be asked of a certain data set? A static expert would be a major problem for Stutt and other imagined users of expert systems. "Second generation expert systems" was seen as the answer, as "SGES" has the ability to interact with the user. SGES could learn, or add to its data base with interpretation and statistics. There would be a reciprocal dialogue between the system and the user. For Stutt (1988), an expert system might model a colleague, with whom the user would dialogue with on a certain archaeological problem. Explanation capabilities, though in the past difficult to add to a program, might now be present in the system if there was enough cross correlated "expert" interpretation of similar data. A list of possibilities could then be called up for the user to add to, or dialogue with.

The problem of suitable vocabulary of such a dialogue was also of interest during the time, and Chadburn (1988) addresses the issue. Her discussion related to the lack of a uniform or standardized classification for archaeological finds in general, and a simple solution might be to gather all agreed upon labels, (agreed upon in the sense that they are in use at any one particular time and place in the world), and link them to one another. The conception of categories and what is in them related to the use and placement of such labels. The user could request a piece of information in their own vocabulary of training, and would hopefully get the same result as another user, requesting information access with a different word. The thesaurus method is recommended for such an application. Educational lexicons could then be set up.

Along such explanatory lines, Rahtz (1988:473) outlined another project with similar intent. The computer program INGRES was used, and the software would take the student through a detailed account of the archaeological process. The student, as part of the teaching role of the program, created an initial research design, site survey and research, detailed excavation of the site, and analyzed all the results in a final report. The available database would be enormous, and the graphic sequence of excavation too complex for the machinery of the day. However, INGRES was by 1988 used in the simulation of a cemetery excavation, with moderate success.

An improvement on educational software for use in archaeology was the dBase IV based system SYASS. It took a student through the excavation procedure in detail, and allowed input from a tutor, so that all levels of experienced "excavators" could benefit from the system simultaneously (O'Flaherty 1988). Students could choose the level of detail and constraints of knowledge they wished to perform under, and thereby teach themselves the methods of field archaeology in a gradual and progressive fashion. Analysis of data also took place within the program, and an assessment was made by the instructor on the student's grasp of data management skills. The SYASS system came on line in October of 1988, and was tested on a wider audience in the summer of 1989.

A further point of interest in the documentation of predecessors of non-linear digital media in archaeology involves the use of interactive technologies. The Leicester Interactive Videodisk (LIVE) project was described as the first program using interactive technology. It served to spur students on in the interpretation of visual images, part of the main task of archaeologists in general. The economy of retrieval, storage, and interaction with software using a videodisk or laser optical disk was greatly enhanced (Ruggles 1988). The potential for education was recognizably enormous, either through student workstations, tutorials, and/or interaction between students and instructor through the technology away from the classroom. Ruggles' project used a combination of objectively oriented response sequences of questions and answers, with which the student could be "marked", and a "free exploration sequence", both of which could monitor progress of the student, though not in a necessarily step by step manner. More importantly, LIVE helped the user-instructor judge the impact of the system in its application. The LIVE project at Leicester was the most advanced of its kind at the time in archaeology.

We have seen that during this period, there had been a progression from the static archive to the dynamic interaction of created texts. Such a movement was foreseen as far back as 1968. Some saw archaeology's stasis, and hoped for a more creative context that would stimulate researchers, and not merely act as a storage facility (Doran and Hodson 1975:318-9). The idea that promoted the study of how archaeologists processed data within their minds, let alone in their computers, existed at the nub for all research using computer applications, and it would guide questions to the formulation of problem-solving devices in software engineering. The data, although subject to often inconsistent though non-random modifications, could be kept whole at all levels by the design of a particular application. The idea of the juxtaposition of different stages of the research process was one of the basic themes behind the archaeological adaptation of non-linear programs.

The programs reviewed above all had indirect reference to the ones that follow. Computer innovation did not exist in a vacuum, and communication, although seldom direct across disciplines involved in creating computer applications for custom use, nevertheless took place. From the earliest beginnings of computer use in archaeology, moving from static storage to incipient associative system, from the

SARG project to that of LIVE, archaeologists and others had progressed in their quest for ways to solve some of the problems of their discipline. Some progress had direct input from computer use, and the results of such input thus furthered research. The next section will explore how other disciplines had, during the same period, created similar progress by their use of actual associative system applications.

3. True Associative System Applications

Two key works stood out in the nascent field of associative system and interactive multimedia. Both were published by Apple computer, and were edited by Ambron and Hooper (1989; 1990). They contained essays and articles dealing with the new wave of associative system research and applications in education and were titled "*Interactive Multimedia*" (1989), and "*Learning with Interactive Multimedia*" (1990). Although none of the case studies were originally from archaeology, their design and context had direct influence on later programs used in archaeological data analysis.

The theory of associative systems had its beginnings at SRI laboratories in 1951 with Doug Engelbart. The "augmentation system framework" expanded the user's self-knowledge, by presenting the human system with the tool system of a computer program. It was the interaction of the two systems, one socialized and enculturated, the other created in a machine, that constructed the earliest multimedia events. The computer was seen as a tool to augment already present human abilities, and not to transform human abilities into something foreign. Such an idea was important because it echoed the sentiment regarding the non-linear application of associative logic in such later programs. One took a very human characteristic of such a thought process and mimicked it in software. With the interaction between human cognitive skills and computer tools, this knowledge and capabilities grew in a step-wise manner. Digital non-linear programs also replicated hierarchical growth in their programming structures.

In 1968, Engelbart demonstrated the capabilities of the 'mouse' (or hand moved keyboard accessory), special keyboard, hyperlinks between video and audio documents, and computer connected individuals communicating with one another. Engelbart's presentation was the true birth of an associative system, even though it was two decades before associative system tools were available in a commercially viable medium (Ambron and Hooper 1989:23). Engelbart would be credited with constructing a "methodology" of associative system.

Brown University was during this period a world leader in the development of both hypertext and associative system. Early applications for the SUN microsystems and the UNIX system included INTERDRAW, INTERPIX, INTERVAL, and INTERSPECT, each performing a particular function of what by 1987 was finally contained in a single program. Eventually, "INTERMEDIA" was born, the system that UNIX users then relied on to keep abreast of associative system and Macintosh's 'Hypercard' software. The programs are very similar, but Intermedia was in general run on a more powerful hardware system. Brown University's program "Context 32: A Web of English Literature" (Landow 1987), was a model application. It consisted of an impressive and massive associative system document, that covered the major figures in English literature from c. 1700 to the present, and presented them within their own historical context through other links or sidelines. Users created their own paths and thus could journey through the corpus at leisure.

The associative system definition of an expert system could contain software able to explain its own actions within the web of associative and analogous thought. The expert environment would involve "user-constructs", replicating the real world (Ambron and Hooper 1989:95). The content of the data base was unstructured unto itself, but interaction with the user structures it by intent, source, implication, and function, as well as style of presentation, the delivery long sought after in previous works. MEMEX was such a system. It performed interactive and other operations using Boolean or numerical syntax. The software instructed the user, guided questioning sequences, informed, amused, or merely allowed browsing with no guidance whatsoever. Its links were necessarily programmed to react to user moves, and did not allow for self-created pathways once the machine was set up in operating mode.

NOTECARDS was a similar system that, while not stressing the expertness of its program, did recapture the semantic and arbitrary links of a true associative system. It ran on a Xerox 1100 machine in the LISP language environment (Halasz 1989). By 1990 it was still de3med to be in the experimental stages. One of the drawbacks that was noted with this program and associative systems in general was that access to information was constricted by the heavy reliance on "navigational" links such as pre-programmed buttons and their destinations. The older concept of linear or hierarchical search, or query based command sequences, might be reinstated into associative system programs to give them an added resource. Ironically, the idea guiding associative system systems was to move away from the static linearity of older search-string based applications. Yet previous ideas and software can be improved and harnessed within associative system applications. The navigational links that information access in associative systems were based upon did not by the end of the period in question have a common rhetoric to guide users familiar with other applications. Once again the problem of standardization reappeared.

The "Shakespeare Project" was also remarkable program, allowing users to do the following:

- "attend" rehearsals with directors and performers,
- "discuss" a play's key issues with interviewed actors,
- view and instantly compare several intriguing different versions of a particular scene,
- design their own "versions" of a crucial scene on a computerized, digital stage,
- peruse an archive of hundreds of historical photographs documenting the rich array of sets, costumes, and props,
- browse through an "electronic" wardrobe and prop room, choosing costumes that suited their own interpretation of the play,
- create their own "case study" of a character's motivation and psychology,
- skip through the expanse of a play almost instantaneously, making comparisons that revealed the large, embracing structure of the play,
- "read" a staged performance with the ease and freedom, starting, viewing, re-viewing, and selecting segments for detailed study (Friedlander 1989).

Three programs were employed in what became the "TheatreGame", one each for scholars, directors, and actors, to be worked within an enveloping program called "OnStage". The software was at the time complex and unique. The CICERO project attempted to guide students of classical civilization at U.C.L.A. through an immense documentation of text and images. CICERO was a state of the art multimedia education tool in use at a large university. The students could tour the baths of ancient Rome on videodisk, or choose some other path. The student could not alter the program, so interactivity is limited, but CICERO's express design was to educate a class. The student collected and collated information to be used in writing term papers on the screen, and could print after the tour is concluded (Frischer 1989). Notably, Bernard Frischer designed CICERO, and the design stemmed from an interest in hermeneutics. Hermeneutics is an interpretation of events or texts based on interaction and experience rather than empiricism. Frischer's background in hermeneutics served as a keystone for the work.

Another multimedia education project similar to the above was called GRAPEVINE, and educated the user in all facets of dustbowl era Midwestern United States, using Steinbeck's novel *The Grapes of Wrath* as a centerpiece. GRAPEVINE was designed to be run on a Macintosh with a CD-ROM player attached. It itself was not a non-linear application. Other programs such as the "Voyage of the MIMI" and the "JASON Project", in which the Royal British Columbia Museum in Victoria, Canada was a participant, were also wide in scope and interactive in nature. Their main thrust was education, employing most of the user's senses.

The issues during this time in the fields of cognitive science, and cognitive psychology in particular were also important to the interactive multimedia applications reviewed in *Interactive Multimedia* (Anderson 1989). "Beyond Einstein" was a associative system project that educated the user about all aspects of post-Einsteinian physics, and also included the historical context leading up to and embracing Einstein's discoveries. Nobel physicist Stephen Weinberg was involved in "Beyond Einstein". The project was for demonstration only, but eventually came on line with the advent of motion picture videodisk.

Grolier Encyclopedia Corporation created an application that allowed hypertextual access to encyclopedic resources. It ran on a Macintosh, and utilized hyperlink like systems of navigation through menus and windows. Other associative system programs worked on the Macintosh if programmed from the ground up. They then, as now, had to be created by expert programmers, and would thus not be applicable to most archaeologists. Such systems also lacked the compatibility of non-linear based applications, which ran with any other similarly based system, creating an infinitely open network.

By the end of this period, there were many applications in use in corporate and academic settings that were not only interactive, but were also constructed with associative system software. It was equally clear that many disciplines had a long way to go in recognizing the potentials of use and adaptation of existing technologies, or the creation of new ones. The positive factor in lagging behind might have been that the technology becoming available would make translation of a discipline's motives and problems into a associative system environment much less painful. However, a cautious 'wait and see' approach was often overemphasized, and educators themselves had to be educated in the gradually burgeoning opportunities.

Some of the problems encountered in the use of associative system applications were akin to losing touch with the real world. Users could easily get lost in a cumbersome and confusing application, and the cognitive load of such enormous databases could be overwhelming. A map of the system was always a must, and guaranteed access to that map was just as important. Both Ambron and Hooper were educators trained as cognitive scientists, and in their second volume (Ambron and Hooper 1990) they addressed important issues concerning "cognitive load" on students, and the psychological effects of computer use in schools. Many more applications were coming on line each month, and some were tested in classroom situations. 1989 saw the introduction of digital non-linear programs running on Macintosh platforms into the U.S. school system at all levels. At the elementary school level, "Hyperrooms" were designed and were in place for educational purposes. Complete interaction was available for students and teachers, with a computer on every desk connected by modem networks to a common resource pool. The hyperroom was an upgraded version of a mainframe system. The hyperroom was interactive in that, while a mainframe facility did not allow the individual workstations to input and override the instructor's access to the mainframe data, newer versions allowed just that, creating real dialogue throughout the classroom, augmenting the natural oral conversation between users.

At Drexel University around the same time, Apple organized the staff and students into a giant experiment. Every incoming student was required by Drexel to purchase a Macintosh of some type, and then was immediately linked to every other personal computer and workstation on the campus. The implications of over 25,000 computers linked together to potentially form a massive interactive storage network were numerous. By 1990, many university departments across North America were experimenting with associative system applications in general. Ambron and Hooper (1990) detailed a few such applications, and also addressed the methods or "art" of construction of such programs, and ways and means of initiating teachers into the universe of multimedia events and systems already in use. The hope was to inspire others to continue what was fast becoming the first grass-roots public revolution in computer technology. Such a technological revolution in access to information was later seen as comparable to Gutenburg's invention of the printing press in 1450.

Comparison of the cases summarized in the previous two sections highlights definite differences. The differences between the non-associative system computer programs and the true associative system applications and Digital non-linear programs will be outlined in the following section.

4. Advances Provided by Associative Systems

Critical comments on the preceding applications are made with the direct experience of relevant advances provided by current associative systems in general, and digital non-linear programs in particular. It should be recalled that each month brings both technique and technology that dispels problems that were, for a time, regarded as daunting. In this way, the physical representation of human thought patterns is made into an object in the world of objects, and not merely a desire or a dream.

The links and data organization in ORACLE were sound, and economical for the early period of computer research. Such applications as site database archives had a direct relationship with later associative systems, even though they were bound by technological innovation in their now indirect borrowing from computer science. Unfortunately, users of ORACLE contended not only with the learning of the access code, which does not seem to us today to be difficult, but also with entry through a DOS. The computer required an in depth and often lengthy sequence of "demand/command" strings where the user 'dialogued' with the program in order to gain correct entrance to one of the many paths in the actual data set. Just contemplating such distance between user and information might alarm a current practitioner. While the DOS feature became by the end of the historical period archaic, the ORACLE system was typical of even the most recent database applications of the same time (Cook and Limp 1981). Such a system type was valuable, but it represented poor economy of information and poor access to users, especially students inexperienced with its retrieval system. The fact that ORACLE was a typical example of both growth in multilinearity and media, while suffering from the leviathan syndrome of data management must have been ironic. However well archaeologists recorded their findings within such a system, the program's design was still limiting.

While AZSITE was impressive in its storage capabilities, it was also oppressive, as the media in which data were presented both for browsing and for input were not only the same, but were page by page imitations of a site record file. The realistic analogies might not be faulted aesthetically, but the program itself was merely a faster way of doing what the recorder already did, and provided no new method of database management (Rieger 1981).

The construction of SARG illustrated a classic problem in archaeology in that it highlighted the differences between the methods and goals of a "historical particularism" with a "comparative method" (Plog 1981). The tableau of often static ideologies was now set on a computer generated stage. Obviously, such a problem remained as long as this dualism was of interest in archaeological theory, and by the end of this germination period in archaeological computer use, had yet to be resolved in linear applications. The other interesting aspect of SARG was that it is one of the original multidisciplinary projects in archaeological computing.

While impressive in its handling of the intermedia of links between objects in an archive, SOFIA suffered from similar archaic user interface and access command strings as did all the others so far reviewed. The entire set of such commands for SOFIA consisted of approximately 1500 acronymal phrases. Even worse, all commands were written and accessed through FORTRAN, a once popular computer language that was surpassed even in the time frame under study, and was also then is quoted as an example of how not to write such a language (cf. Goodman 1988).

Although the 'philosophical' motive behind the SATIN 1 system was empirical, with the concentration on moving away from the ambiguities of human perception, the system was of interest because it identified a problem often ignored in archaeology. The problem was of the identification of differences between the recorded event of an archaeological find, its description, and its interpretation(s). All levels of occurrence were eventually included in the later applications, but there existed an indirect precursor to the inclusion of all archaeological "events" in SATIN 1. The operating system was made up of a set of "Boolean, or numerical matrices" (Bourelli and Chouraqui 1981). Data were organized by fields, or sets of linearly related data. The organization of the information was very typical, although the ultimate goal of the SATIN 1 application was at the time fairly unique.

The amount and the depth of links in the FRANCIS data base was both a positive and a negative, for, as massive as the cross references might be, quick access to particular articles was denied by FRANCIS. Much previous knowledge within an area of European prehistory must have had to have been present to use FRANCIS with any efficacy. FRANCIS was a system for the professional, and as such it risked ghettoization. One of the aspects that period computing in archaeology focused upon was information access and economy of time. FRANCIS lacked the foci of other albeit much smaller systems, but served as an example of the great lengths the operator could move to with an ordinary linearly linked database.

Although all features of the PLUTARCH program were at once rendered archaic by then current paint tools, especially tools from industry standard graphics. It was the idea that lay behind PLUTARCH that pointed in the direction of much later developments in graphics, and all the manipulations that have become possible with them. The motive for PLUTARCH's construction was the production of high quality computer generated diagrams and charts for hardcopy publication. Most of the basic functions of a modern graphics package are foreshadowed with PLUTARCH, including scalograms, dendrograms, circles and other plotted polygons, cutting and pasting of items, deletion, and the positioning of text and graphics. Functions were accomplished with the use of the "light pen", which acted as a "mouse". For archaeologists in particular, PLUTARCH was a boon, and the ideas that were captured on computer for printing created a new level of high definition graphics for investigators. The graphics within PLUTARCH could be interlinked with statistics, maps, pie-charts and other data media to produce the finished work. The interesting and archaic aspect of PLUTARCH is that it was not designed primarily with software use in mind, but to produce quality documents for hardcopy perusal.

The discussion in Cooper and Richards (1985) is also worthy of the critical comments of hindsight. The discrete yet intermingling quality of reviewed data sets evoked images of the aforementioned object oriented programming. Here, discrete units of language were packaged in "containers", acting on specific requests and performing particular functions. The containers were ordered in a hierarchy of specificity of function, and, at least in non-linear programs, requested in the form of messages sent to the program by the user were processed in an ever ascending order of command levels. For example, if the application could not show the requested material to the program's operating system, the program would eventually tell users that their request could not be fulfilled. Responses as disparate as a wrong file name, to a complete lack of such data might have been the computer's answer.

Even by 1990, the archaic aspect of Carver's (1985) article was that the author asked for standardized pieces of text, serving as the interrogators of a soon to be standardized computer archive. While one might have agreed with Carver's sentiments regarding the pace and language of adjustments archaeologists must make in order to take advantage of what creative opportunities the computer might present, the idea that any new language will or should become a standardized one was later seen as a constraint. In fact, associative systems made an idea of such a language redundant. Associative systems also transcended argument towards a particular type of computer technology or how archaeologist's might talk about that technology.

It is also clear that for Rielly (1985), the computer had the potential to contribute far more than just a series of more complex manipulations of static data than could be accomplished manually. The problem of equal access to data by users of different level machines was one that might be met with a technological standardization of potential applications *via* each type of machine. Rielly apparently thought that such a standardization was more important than the idea of homogenizing the "What?" of archaeological data. However, Rielly was unlikely to see a movement in such a direction from the computer industry at the time. The industry was, and is, competitive and mostly profit motivated. Instead, it was the hope that archaeologists would have access to many different hardware set-ups and programs to suit all abilities and needs. The standardization of media, even a medium that in theory can house all types of possible representations and stories, is still ultimately monolithic. Standardization contradicts part of the philosophical intents of the associative system, which allowed a dynamic creation of new applications, and hence changing "standards" . Yet Reilly's article was the first to address in a detailed manner idiosyncratic aspects of the computer and the user in an archaeological and general context. At the time, the prestige factor in being computer literate, and owning or developing custom programs could not be underestimated even in scientific circles. The development of such software was just as likely to contribute to the non-cooperation and competition amongst scholars as it was to create an atmosphere of cooperational holism. Rielly "...does not subscribe to the belief that archaeological data are somehow passive objects, or just "things in themselves", waiting for discovery. Nor is it likely that field archaeologists rely on serendipity to isolate the entities that they recognize and record." (Reilly 1985). Instead, the constructs of the investigator's historical consciousness allow for the occurrence of such events, and it is to the archaeologist's intuition that the innovation of computer technologies would have to look for ultimate guidance.

Even in 1987, Wilcock's configuration was archaic, although apparently affordable. It should be noted that the computer systems in evidence at the time in the academic community were there because they were inexpensive. The prevalence of older systems was not the fault of the researcher alone, but had to do with the other problems outlined, funding and disorganization. Other of Wilcock's recommendations might have been more generally agreeable, but many pertain to the use of kinds of linear systems, with all of their inherent problems.

Biek's article addresses the potential storage and retrieval of whole assemblages, in three dimensional laser read graphics, and laser read text. The key to early videodisk technology was speed and amount of storage capacity, both of which were at the time exhibited in exemplary fashion by optical disks and drives. The DOMESDAY 86 software application was the predecessor to yet more recent and industry standard drives, with which the Macintosh, for instance was in some cases, entirely compatible (e.g., the NeXT computer, and the SUN microsystems optical drive). It seemed like it only remained for departments to avail themselves of the then present technology to register many leaps forward in the pragmatic realms of economy and efficiency of data management.

By 1990, Ryan's program seemed only in the experimental stage, but the early use of "system mapping" as a way to enter the program itself followed concurrent associative system events of note The ideas of interactive media and graphics were combined in Ryan's unique if somewhat limited discussion. For instance, does an expert system require artificial intelligence? For the time the short term answer must have been no, for technological capabilities had not yet been able to provide "AI". Seventh generation computers were said to supposedly have an intelligence of human quality, but some Japanese corporations were then merely beginning work on the so-called fifth generation. However, if enough possible responses to user questions were available, then even the programs of the day might have been able to 'think for themselves' based on certain archaeological and theoretical paradigms. The program might answer questions, or at least participate in a dialogue with the user. The machine might also have been able to critique the user's case or model by comparing it to its own programmed model or sets of alternatives. A dialogue would be created. The system might cooperate with the user towards an explanation for certain findings or patterns, more "democratic" than setting up the computer to tell the user what they are doing wrong, or merely critiquing (Stutt 1988). The best attempt at "AI" during the period in question was based on an AES system or "arguing expert system" program. AES simulated as closely as possible an exchange between expert human actors, even if only one is human, and one programmed. Arguments were sustained in the usual manner, with the employ of the expert's reserve of knowledge of the subject. It was deemed unlikely that computer programs would be able to work in the analogic or associative realms as well as humans, but such a period sentiment was of course subject to the same historical processes of invention and hindsight as corresponding statements emanating from our own day are. However, using "rock logic", or sets of linear relations and given parameters, the machines of this earlier time would ideally "argue" well enough to dialogue with a human expert.

The model that Stutt introduced was in fact an old one in Western philosophy, and took the form of a chess-like game, another well-tried program in the computer world. Moves followed explicit rules, captured and communicated in a symbolic medium, with actors taking turns defending their own argument or attacking the other. There are winners and losers, and also a means to assess the strength of the overall argument.

It appears that Stutt limited discussion by masquerading a linear and dogmatist logic in the guise of a dialogue. The problem with AES systems, of which Stutt's was taken to be typical, lay in their inability to mimic more than a few human aspects or ranges of thought. The analogic and associative links, of which the human perceptive faculty is primarily composed, were then beyond the arguments of Stutt's systems. Such logic had its place in the scientific realm, as part of a nomothetically deductive path. However, the linear path was merely one manner of exposition, and it has been absorbed into the archaeological discourse at the expense of other often more creative alternatives.

Non-linearity introduced a truer form of dialogue than did the AES system. The links within such a program could be modified, something impossible to do within the paradigms of logical discourse, or "rock logic" (De Bono 1990). It would also seem to be very difficult for Stutt or others to have programmed into a computer some of the capabilities he imagined might taking place in such software, such as the memory of opposing arguments' style or location of language, delivery and strength of argument.

Stutt quotes Wylie (1987:5) in clarifying that analogic reasoning would be a help in drawing conclusions archaeologically, from a given set of inferences. However, Wylie immediately transforms analogy into a form of deductive reasoning, with its basis in logical relationships (Stutt 1988). Yet the associative system application aided in demonstrating that the hypothetico-deductive relation in the human sciences rests fundamentally on analogy, and that analogy is not a form of deductive logic. Analogy could not be programmed into a machine, as the weight of the entire programming effort rested itself on analogy and similar relations. The thought process of the human mind was known to exist within a recursive structure, and little would be gained by replicating a recursive formula while basing the programming upon a linear set of relations. Such a set of relations would couch it in the limiting language of symbolic logic. Associative systems, although related indirectly to the AES attempts in particular applications, realized a much closer mimicry by dissolving logical relationships, and putting control of all linkages to be made within the program with the user. Only then could the user dialogue with the machine.

Similarly, the apparent period problem with Chadburn (1988) was that if the reference itself were not made interactive, then it would become static and archaic at the same time. Over a century of archaeological work had produced not only vast quantities of data, but also vast lists of terms and labels to cope with such items, and to include them in this discourse. If science is a process of attaching names to "things", then the process of "renaming things named" is also an integral part of this work. The indexing approach was offered as an alternative to the thesaurus, but, where there was no governance of labels by meanings that are attached to them, the potential inflexibility of the thesaurus gives way to the potential chaos of unrecorded, unlisted meanings of listed words. Nascent associative systems of the period had a similar problem of vocabulary relations in that their programming language used certain terms by certain restricted definitions, and the programmer had to pay attention to a given set of restrictions and none other, if the command string was to be successful. Chadburn (1988:396) encountered the same problem with how to define meaning across users, and thus letting them know that their colleagues "mean what they say", in a discipline that might not always allow its students to say what they mean.

Furthermore, Callow (1988) detailed a long term archaeological project in which the computer acted as a communicator of past work to the next generation. The La Cotte site in France was the subject of the discussion, and INGRES was the application, and Callow's piece was one of the first in the literature to spell out such claims for the computer's enhancement of any particular archaeological project. The associative system leaves open the possibility of return and modification in the future. Such a project can become the basis for a long term experiment in data organization and storage. The operating system for the application of INGRES relied on a DOS, and therefore greatly hampered the ability of the user to "excavate" or analyse in a quick and economical manner. The disk operating system command lists did grow simpler each month during the latter years of the 1980s, and the five commands listed for the INGRES application would not seem to be difficult to commit to memory. Setup of the dialogue screens was archaic and linear, and overall the effect of INGRES was simple, although extremely complex to program during its day. It was typical of many such applications that existed on certain types of hardware. Much programming was needed to get simple results in software. However, INGRES was interactive, and involved use of created text fields and data bases (even though such fields were created from an already available and static data set), and most importantly was a sound educational tool for students in archaeology. The INGRES application was eventually improved by adding graphical representation and color photographs from a videodisk. The technology was then available to make Rahtz's educational program very sophisticated, but it was rapidly superceded.

The technological problems mentioned in Ruggles (1988) largely disappeared by the end of the historical period, and the potential for educational applications using CD-ROM technology were not underestimated. More data presented by digital non-linear programs or some other associative system application could be stored on high density optical drives than on hard disk. The write-to program that Ruggles envisioned for the then near future was already available in Japan. It was called "Write to ROM". The name was of curse a famous contradiction in terms, as it allowed authoring changes to take place on the disk, and could provide true interaction with the program's data base. Digital non-linear programs allowed interaction on a smaller scale, and were to be expanded with the amount of hard disk expansion and addition of space in memory. The goal of all educationally oriented projects in archaeology was to present the most flexible and interactive software to the student as technologically possible. But, as stated before, it remained the creativity of the user that dictated how far one could go with such software, more than it was the limitations of a particular technology.

The Leicester project was innovative in user interaction and creativity, as it allowed the user to impose an abstract structure on the data base. The abstractions existed apart from the data, and did not change the base of data to something other than originally programmed (Ruggles 1988:528). The protection of the data had the advantage that associative systems replicated. The data could remain "aloof" from the user's manipulations by staying on a different level than the user's interpretations. Other future users would not be distracted by previous work, if they wish to use the "original" or "unmarked" data set in their analyses. To this end, the LIVE software became available in the autumn of 1989. The LIVE project was not as interactive as hypermedia programs of the day but it was much closer than previous attempts. As soon as Interactive ROM disks and drives appeared, incipient uses of associative system environment tools were activated to a much greater extent. The LIVE project was also linked to an associative system through its keyboard and mouse operational systems. Features within the software allowed the user to click the mouse with a cursor in areas of the screen to evoke a response. Interactive screens were similar to the button navigational function in Apple's 'HyperCard', but such screens were static as they only allowed the user to navigate, rather than actually create, the paths of navigation. Operation of the mouse shortcuts commands evoked the Macintosh user interface by the distinction in the program between a "click" and a "double-click", initiating separate though related actions on the part of the computer. Icons were also employed in the Leicester application, and generally the operational interface was for its day impressive. However, it was still fraught with command lists, a holdover from the days of the monopoly of DOS codes. For example: a list of 16 mouse maneuvers included the following *to run from start*: left click towards the top or bottom of screen, *to freeze frame*: double click towards left or right of screen, *next frame*: right click towards right of screen, *previous frame*: left click towards right of frame, and so on (Ruggles 1988:541). Even so, during the thirty years of nascent motion towards true associative systems in archaeology, the LIVE project remained the most up to date example of interactive technology in the archaeological realm.

5. Conclusion: perennial implications

This application of associative system relieved the tension between extremes of classification to some extent, because the detail of the record sheet not found in interpretive works is restored. The original names are important in two fundamental ways. The field identifications express the actual moment of recovery of an archaeological item, giving it the status of an artifact. All further work, whether in the analytic or interpretive stages, stems from this moment of discovery. As well, the process of cataloguing artifacts, used in all further research steps, is impossible without at least a casual attempt at field labeling. To name things is to classify them. One can also create new classifications that ignore original field names, just as in the laboratory. With a functional analysis, variety of raw material used in the manufacture of particular archaeological and/or indigenous classes of artifact is underestimated, while the remainder of potential classes is silenced. The total number or variety of "things" is underestimated. However, when assemblages are small, miscellaneous categories are necessarily larger, due to the lack of artifacts with which to compare unidentified objects.

The actual excavation procedure was also interesting in the associative system context. Some archaeologists made a distinction between the arbitrariness of scientific excavation and the arbitrariness of the cultural deposit that has undergone non-random postdepositional translation (Schiffer 1976). The "N-Transforms" of Schiffer (1976) were merely the identified "C-transforms" of the investigator. What was meant here was that scientifically identified taphonomic processes were part of this cultural knowledge, and as such also did "transform" the archaeological record. The predepositional throwing out of trash into a heap is also analogically identified by our own culture, which disposes of its garbage in a similar fashion.

Translations occur when archaeologists decide what an object is. However, such decisions happen repeatedly, and it is the changing of what we think things are which is an interesting process to present. If forms of perception in archaeology are somehow different from forms occurring in other disciplines, then a "phenomenological" stance would be consistent with the idea of "perceptual relativism".

The archive of archaeology is created by a process of classification and storage. Data are stored and accessed by class, in a taxonomy of the archaeologist's creation. Alternatives to a certain taxonomy could be pursued more assiduously by associative non-linear data presentation systems. Associative systems allowed many translational events in the archaeological process, from excavated item to catalogued number and name, to be presented. It also allowed users to construct their own personal paths. The storage of archaeological information was given fluidity. The archive was moved from the static location of linear storage. Linear storage was exemplified by most period attempts at archaeological data management, and hardcopy resources.

The philosophical themes of Merleau-Ponty (1935; 1964) might be used as a theoretical framework for non-associative systems. The "phenomenology", or study of phenomenon, holds within it many understandings of its "ground". This "ground" can mean human perceptual reality. The ground, both in literal and phenomenological senses, holds all that archaeologists wish to understand. Territory investigated by the archaeologist is the ground of past human experience, but it is also linked with the experience of the present. The discovery of an artifact or a site is an experience of a new phenomenon, created by the interaction of archaeologist and world. Hermeneutic interactions create archaeological knowledge, with all its conflicting views.

The "newness" of the archaeological events or phenomenae continue to be recreated during the archaeological process. Analogy, associative logic, and "common-sense" were during the time all cited as "non-scientific" factors exerting their influence on the scientific process. The combined influences of "non-logical" variables was seen to create archaeological knowledge. Such influences also guided in the creation of all interpretation based upon archaeological knowledge, and directed scientific enquiry back to the data. Yet the data themselves are often renamed and recreated, thereby becoming new phenomena once again.

A science, like any human endeavor, is subject to the changes inherent within those working within it. Sometimes the extent of inherent changes and their effect on a discipline's state of knowledge can be taken for granted, or statistically ruled out as a given. The sum of scientific knowledge is the total of the changes taking place within corresponding research. We cannot hope to claim a complete knowledge of even the processes of scientific enquiry until such a time as its inherent changes are brought to light in a systematic manner. They should not be subject to a reduction of method or statistic. Such changes might be better understood in the associative system context.

To keep track of all the constant and multitudinous changes, a student might advocate their being kept in a dynamic archive. Such a repository might allow the translation process, constantly occurring in archaeology, to be accessed and studied. Some portion of that process may be changed. The mere analysis of it may be satisfying enough, all the while creating changes through such manipulation. The "phenomenology of perception" implies that change is made through interaction. The archive, if not used, does not "exist". It does not exist not only in experiential terms, but more importantly for archaeology, in the practical terms of access to knowledge. Without the remainder of archaeological work done previous to the introduction of associative systems in archaeology, one could not build upon it, and thus we risk going in circles over points that may have been resolved to the consensus' satisfaction years ago. As well, such points resolved during past work may need to be reviewed, another impossibility if the data are not readily available.

Interaction involves not only the data and the user, but all the links amongst related data. Links are originally set up by archaeological recorders on site, and recreated through the user. A much greater intimacy of contact was to be created in archaeology between the story told and its tellers over the course of the development of non-linear interfaces. Within such an intimacy, it was hoped that students would further the grand aims of archaeology, including the understanding of humanity's present story by directly experiencing the present, through the indirect reflection of its past.

References:

[1] Ambron, Sueann and Kristina Hooper, *Interactive Multimedia*, 1989, Microsoft Press, Redmond, WA.

[2] Anderson, Thomas Beyond Einstein, In *Interactive Multimedia*, edited by S. Ambron and K. Hooper, (1989), 193-214, Microsoft Press, Redmond, WA.

[3] Biek, R.L. Archaeology, Science, and Domesday, In *Science and Technology, Proceedings of the Glasgow Conference*,. edited by A.R. Hands and D.R. Walker, (1987), 541-543. BAR series 146 (ii), Oxford.

[4] Bourelli, Louis, and, Eugene Chouraqui, The SATIN I System, *In Data Bank Applications in Archaeology,* edited by Sylvia Gaines, (1981),130-140, The University of Arizona Press, Tucson.

[5] Callow, Paul Across the generations: A long term computing project, *In Computer and Quantitative Methods in Archaeology,* edited by S.P.Q. Rahtz, (1988),453-470, BAR series 446 (ii), Oxford.

[6] Carver, M.O.H. The Friendly User, In *Current Issues in Archaeological Computing,* edited by M.A. Cooper and J.D. Richards, (1985), 47-62, BAR series 271, Oxford.

[7] Chadburn, Amanda Approaches to controlling archaeological vocabulary for data retrieval, *In Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 389-398, BAR series 446 (ii), Oxford.

[8] Cook, Thomas Glenn and Frederick W. Limp, The ORACLE Computerized Information Retrieval System, *In Data Bank Applications in Archaeology,* edited by Sylvia Gaines, (1981), 57-66, The University of Arizona Press, Tucson.

[9] Cooper, M.A. and J.D. Richards, *Current Issues in Archaeological Computing,* 1985, BAR Series271 Oxford.

[10] de Bono, Edward *I am Right, You are Wrong: from this to water logic,* Viking, New York, 1990.

[11] Doran J.E. and F.R. Hodson, *Mathematics and Computers in Archaeology,* 1975, University of Edinburgh.

[12] Dunnell, R.C. Methodological Issues in Americanist Artifact Classification, *In Advances in Archaeological Method and Theory,* edited by M.B. Schiffer, 9 (1986), 149-194, Academic Press, New York.

[13] Friedlander, Larry, The Shakespeare Project, In *Interactive Multimedia* ,edited by S. Ambron and K. Hooper, (1989), 115-142, Microsoft Press, Redmond.

[14] Frischer, Bernard, Links or Stories: A Compromise, In *Interactive Multimedia,* edited by S. Ambron and K. Hooper, (1989), 299-302, Microsoft Press, Redmond.

[15] Gaines, Sylvia, *Data Bank Applications in Archaeology,* (1981), The University of Arizona Press, Tempe.

[16] Goodman, Danny, *The Complete Hypercard Handbook, second edition,* 1988, Bantam, New York.

[17] Halasz , G. Frank, Notecards: A Multimedia Idea Processing Environment. In *Interactive Multimedia,* edited by S. Ambron and K. Hooper, (1989), 105-110, Microsoft Press, Redmond.

[18] Hugget, J. Expert Systems in Archaeology, In *Current Issues in Archaeological Computing,* edited by M.A. Cooper and J.D. Richards, (1985), 123-142, BAR series 271, Oxford.

[19] Landow, G. *Context 32: Using Hypermedia to Teach English Literature,* (1987), AEP IBM Conference Proceedings, 1987.

[20] Le Maitre, Jacques, SOFIA: A Data Base Management System Applied to Archaeology. In *Data Bank Applications in Archaeology,* edited by Sylvia Gaines, (1981), 123-129, The University of Arizona Press, Tempe.

[21] Martlew, Roger, *Information Systems in Archaeology,* New Standard Archaeology, 1984, Alan Sutton Publishing, London.

[22] Merleau-Ponty, Maurice *Phenomenology of Perception,* RKP/HP, London, 1964 *Signs,* (1935), Northwestern University Press, Chicago.

[23] O'Flaherty, Brendan, The Southampton-York Archaeological Simulation System. In *Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 491-498, BAR series 446 (ii), Oxford.

[24] Patrik, Linda, Is There an Archaeological Record? In *Advances in Archaeological Method and Theory* , edited by M.B. Schiffer, 8 (1985), 27-46, Academic Press, New York.

[25] Plog, Fred, SARG: The Computer in a cooperative Effort, In *Data bank Applications in Archaeology,* edited by Sylvi Gaines, (1981), 46-56, The University of Arizona Press, Tempe.

[26] Rahtz, Sebastian, A resource-based archaeological simulation, In *Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 473-490, BAR series 446 (ii), Oxford.
[27] Richards, J.D. Standardizing the Record, In *Current Issues in Archaeological Computing,* edited by M.A. Cooper and J.D. Ryan, (1985), 93-102, BAR Series 271, Oxford.
[28] Rieger, Anne, AZSITE: The Arizona State museum Site Survey Data Base, In *Data Bank Applications in Archaeology,* edited by Sylvia Gaines, (1981), 27-45, The University of Arizona Press, Tempe.
[29] Rielly, P. Computers in Field Archaeology: Agents of Change? In *Current Issues in Archaeological Computing,* edited by M.A. Cooper and J.D. Richards, (1985), 63-78, BAR series 271, Oxford.
[30] Ruggles, Clive, Software for the Leicester Interactive Videodisk Project, In *Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 523-542, BAR series 446 (ii), Oxford.
[31] Ryan, N.S. Browsing through the stratigraphic record. In *Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 327-334, BAR Series 446 (ii). Oxford.
[32] Stutt, Arthur, Expert Systems, explanations, arguments and archaeology, In *Computer and Quantitative Methods in Archaeology, 1988,* edited by S.P.Q. Rahtz, (1988), 353-368, BAR series 446 (ii), Oxford.
[33] Wilcock, J.D. The "PLUTARCH" System. In *Computer Applications in Archaeology, 1974,* Proceedings of the Annual Conference Organized by the Computer Centre, edited by J.D. Wilcock, (1974), Birmingham University Press.
[34] Wilcock, |J.D. Past and future directions in Archaeological Computing, In *Science and Technology: Proceedings of the Glasgow Conference, 1987,* edited by A.R. Hands and J.R. Walker, (1987), 497-507, BAR series 146, Oxford.
[35] Wylie Alison, The Reaction Against Analogy, In *Advances in Archaeological Method and Theory,* edited by M.B. Schiffer, 8 (1985), 68-103, Academic Press, New York.
[36] Wylie, Alison, *Simple analogy and the role of relevance assumptions: Implications of archaeological practice* unpublished paper, (1987), University of Western Ontario, Guelph.