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Feeney, Mary

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Information Technology in Humanities Scholarship British Achievements, Prospects, and Barriers

*Mary Feeney, Seamus Ross**

Abstract: The British Academy and the British Library Research convened the Humanities Information Review Panel in April 1990. The Panel's brief was to examine all aspects of the generation, storage, and use of information in the humanities, and to look especially at the new methods of handling information provided by the use of computers, telecommunications, and other associated technologies. Section 2 of this concise report outlines the impact of new technology on scholarship (text, data, images, sound, combined sources, electronic communication, tools); section 3 discusses new developments and the change of the traditional image of the humanities scholar, section 4 describes training and support, network access and equipment, research infrastructure, information resources, regulatory issues and funding; section 5 summarises the recommendations of the Panel.

Section 1

Background

The use of computerised tools is becoming more widespread in the creation, collection, storage, and dissemination of scholarly information and this is beginning to have a pronounced effect on patterns of information use and communication. Significant improvements in technology-faster processors, large capacity storage devices, higher resolution screens, faster and better networks, more powerful and flexible software-have enabled humanists to make better use of computers in their work. The speed and scope of such developments

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make it imperative that the institutions and information professions which serve the humanities are aware of the changing needs of their clientele. Libraries, museums, archives, publishers, information providers, and computer services all have a part to play. For this reason the British Academy and the British Library Research and Development Department (BLR&DD) convened the Humanities Information Review Panel (HIRP) in April 1990. The Panel's brief was to examine all aspects of the generation, storage, and use of information in the humanities, and to look especially at the new methods of handling information provided by the use of computers, telecommunications, and other associated technologies, with a view to helping information providers reassess and improve their services. The Panel acknowledged the need for adequate funding not only for providers, but also for the community of users to be equipped, motivated, and trained to take advantage of the opportunities offered by information technology.

The Panel brought together researchers and scholars in the humanities from a wide variety of disciplines and backgrounds, along with representatives from the library and information professions (see Appendix 6.1). The deliberations of the Panel produced a mass of documentation too large and disparate for publication. Therefore, after asking a group of independent experts to review the material, the sponsors commissioned a concise report for general publication which focused on one very important area of the Panel's discussion: the use of information technology in the humanities.

The Panel's deliberations have taken place during a period of major structural change in the funding of higher education. Since most scholars in the humanities belong to this sector, few remain untouched by these developments. The changes have occurred against a general background of declining resources, in real terms, for higher education, along with increasing pressure on the funds available for the maintenance and development of the collections of books, archives, and artefacts which are the principal resources for scholarly research in the humanities. At the same time, the recent rapid and underfunded expansion in student numbers in higher education have dramatically increased teaching loads. This makes the most valuable of resources for research in the humanities-time-increasingly scarce. Thus the Panel has taken a wide view of the information technology needs of the humanities, of the barriers to research, and of the ways in which these might be overcome.

There is an increasing will amongst humanists to change information and communication practices as a positive reaction to the potential of technology. As more scholars become aware of the benefits the use of computers bring to the work of colleagues, the demand for an equitable share of allocations for equipment, training, and support will grow. A variety of financial pressures on higher education and on repositories of books, artefacts, and manuscripts also makes change essential. This situation presents an opportunity for the community of scholars in the humanities, for information providers, and, above all, for

those responsible for funding research, libraries, and other repositories on which scholars depend, to take a positive role in the improvement of the provision for resources.

The following section outlines the impact of new technology on scholarship. It suggests a high level of activity, but in reality these projects, and numerous others that might have been included, are being undertaken by only a small percentage of humanists. Many difficulties still confront scholars: problems of gaining access to and using resources; shortage of equipment, skills, and support; difficulties of networking; and problems encountered by suppliers in converting material into electronic form. All these areas need greater funding if resources are to improve. Recent surveys, such as that undertaken by the Office for Humanities Communication (Mullings, 1992), suggest that, although many academic departments now have computers, the use of information technology in the humanities remains very patchy. The overall picture, then, is not one of widespread use of new technology, but rather one of peaks and troughs, with high levels of activity and achievement in some areas, matched by low levels in others. Some of these difficulties are detailed in Section 4, and they are taken up again in Section 5 which summarises the recommendations of the Panel.

Section 2

Information technology and scholarship

2.1 Introduction

Humanists have used computers since the 1950s, but until the 1980s usage in Britain could be described as occasional. Initially computers were mainly perceived as number-crunchers and most data were numerically coded for input and analysis. The questions asked of these data were by and large statistical and eventually the 'quantitative paradigm' took hold in some humanities disciplines, such as history and archaeology. The gradual realisation that computer hardware and software could manipulate symbolic as well as numeric data had a remarkable effect on the kinds of projects for which it was considered possible to use a computer. Now it is widely considered obvious that information need not be numeric to find a place in humanities information processing.

Scholars, whether computer users or not, will recognise the classification of primary source material as text, data, images, or sound. To some extent the discussion of computer-based projects is best viewed from the vantage of the raw materials of scholarship. Besides these at least two new dimensions must be added: electronic communications, which permit the transmission of information, and combined sources (hypermedia), which provide a platform for working with several different types of raw material simultaneously. The dis-

tinction between text and data is somewhat artificial. Historians and archaeologists often work with discrete chunks of information which can be better collected, manipulated, stored, and output in structured form. Some of the new tools for working with textual data have blurred this distinction, but many data are still better handled as discrete units by statistical packages and database management software. To assess the impact of new technology on humanities scholarship the Panel concluded that the developments should be viewed in terms of the type of information involved.

If the use of computers for word processing, electronic mail, and simple searching of on-line databases or catalogues is excluded, the computerbased work done by humanists can be divided into five categories: the provision of general resources, such as library catalogues, dictionaries, and bibliographies; the retrospective conversion of manuscript or printed sources into machine-readable form; the creation of specific research tools, such as databases and image banks; the use of computers to extract summary data from larger electronic resources, such as population censuses and tithe surveys; and the computer-assisted investigation of hypotheses and the development and testing of models. The first three categories often require much scholarship, provide the basic resources for further research in the humanities, and form the foundation for the last two categories. The use of computers to investigate hypotheses which must be tested with large and complex datasets has led to advances in archaeology, history, literary studies, and philosophy. Sir Anthony Kenny's study of The Aristotelian *Ethics*, which demonstrated that books ascribed to both the Nicomachean Ethics and the Eudemian Ethics actually belonged to the latter text and not the former (Kenny, 1978), would have been difficult, if not impossible, had he attempted the investigation manually. Computers have given humanists the facilities to extend the agenda of enquiry.

The projects described in the following pages illustrate the impact of new technology on scholarship. The coverage is not comprehensive; the projects cited are intended as significant, predominantly British examples of what has already been achieved, the work which is currently underway, and the new possibilities which are beginning to open up for the future. Inevitably there are gaps. The discussion of sound, for instance, introduces research into sound cognition by musicologists, but the examination of text excludes research into the understanding of text, which it might have included. The Panel also recognised that museums, libraries, and archives are producing electronic catalogues and registers. As with computer-assisted scholarship this activity appears sporadic and not universal. Major institutions, such as the British Museum, the National Museums of Scotland, and the Bodleian Library, all have computerisation programmes, but smaller institutions often lack the resources, equipment, and training necessary to undertake similar programmes. These projects are not fully detailed here although we have discussed in the concluding section some of the ways problems facing these institutions might be addressed. Two North

American surveys, one by Michelson and Rothenberg (1992) and an earlier one by Gould (1988), and the European Science Foundation's survey edited by Genet and Zampolli (1992) have charted work outside Britain.

2.2 Text

Electronic texts from manuscripts and printed sources are now available in different formats and from a number of different sources. Some projects try to be comprehensive while others aim to collect a particular corpus of texts. Some are combined with integrated software for analysis and can be accessed only by means of that software. Others offer plain text files which can be processed by software chosen to meet the needs of an individual scholar.

The Oxford Text Archive was established in response to the growing number of electronic texts prepared by individual scholars, major research projects, and publishers. It is a specialist facility supported by Oxford University Computing Services (OUCS) and serves the academic community by providing archival and dissemination facilities for electronic texts at low cost The primary purpose of the Archive is to ensure that machine-readable texts prepared for scholarly purposes remain available to the academic community. Because the texts come from so many different sources they vary considerably in format, accuracy, and type of coding, but many provide suitable sources for future scholarship.

Advances in computer storage and retrieval have made the construction and use of large text corpora much easier, and this has widened the potential for research. A corpus differs from an archive in that it consists of a collection of texts gathered according to particular principles for a specific purpose. One of the best known, the *Thesaurus Linguae Graecae (TLG)* provides in machine-readable form the work of 3,157 authors who wrote in Greek from the time of Homer to AD 600. It has been claimed that the 57 million words in the corpus represents 99 per cent of the surviving Greek literature. The TLG accommodates different approaches to analysis of the text and this has encouraged the production of a number of text handling packages designed specifically for work with this corpus. The advantages of electronic corpora, first demonstrated among classical scholars, are now perceived by scholars in other disciplines. *The Dictionary of Old English (DOE)* project, compiled at the University of Toronto, has converted the whole corpus of Old English texts to machine-readable form and this is now available on magnetic tape, or for searching on-line, via the Oxford Text Archive. Similarly, the CURIA project aims to create a text archive of all Irish material up to at least the end of the Middle Ages as a *Thesaurus Linguarum Hiberniae,* under the auspices of University College Cork and the Royal Irish Academy. The availability of corpora in electronic form makes it possible for historians and literary scholars to ask challenging questions of their sources which require selection, manipulation, and organi-

sation of vast amounts of data or the identification of minutiae in mountains of information.

Linguistics is one area where text corpora are being developed on a large scale. The results are proving invaluable not only in lexicography and the preparation of language reference works, but also in the development of speech recognition for computers, machine translation, computer-assisted language learning, and 'intelligent' word processing software. To meet the demand for larger and better corpora the British National Corpus (BNC) project began in 1991 as a collaborative venture by Oxford University Press, Longman Group UK Ltd, W. and R. Chambers, Lancaster University's Unit for Computer Research in the English Language, Oxford University Computing Services, and the British Library with substantial support from the Science and Engineering Research Council, and the Department of Trade and Industry. The BNC will contain data from a wide range of sources in order to form a representative cross-section of the styles of current written and spoken British English. About 90 million words will be taken from written sources and up to 10 million words from spoken British English, recorded specially for the BNC. Once the 100 million words are collected, linguistic information or annotation will be added to the Corpus. Ultimately it will provide the foundation for dictionaries, and studies of language usage, such as investigations of deviation between written and spoken registers.

Many projects derive from academically funded work, but it is an indication of the growth of this area that commercial publishers are now investing in electronic texts. The Oxford Electronic Text Library from Oxford University Press (OUP) includes the works of Jane Austen, Coleridge, Wordsworth, Dikkens, Chaucer, Locke, and Hume and is distributed in ASCII format on floppy discs. While OUP's collection is increasing the numbers of major canonical authors available in electronic form other groups are concentrating on the creation of comprehensive resources in specific areas. Chadwyck-Healey Ltd is preparing the English Poetry Full Text Database for publication on Compact Disc-Read Only Memory (CD-ROM). By the summer of 1994 a machine-readable fulltext database encompassing the works of 1,350 poets from the Anglo-Saxon period to the end of the nineteenth century will be available on a set of four CD-ROM discs.

Besides creating text corpora, scholarly effort and commercial funding have gone into the provision of reference works in electronic form. The recently completed *Oxford English Dictionary (OED) Second Edition on Compact Disc,* published by OUP, makes use of specially designed search and retrieval software (Figure 1). This electronic version of the twenty-volume dictionary contains 60 million words and allows researchers to explore the OED at a depth which does full justice to its encyclopaedic potential and to carry out sophisticated searches not feasible using only the printed version. For example, the system supports both browsing and searching through quotations, definistions,

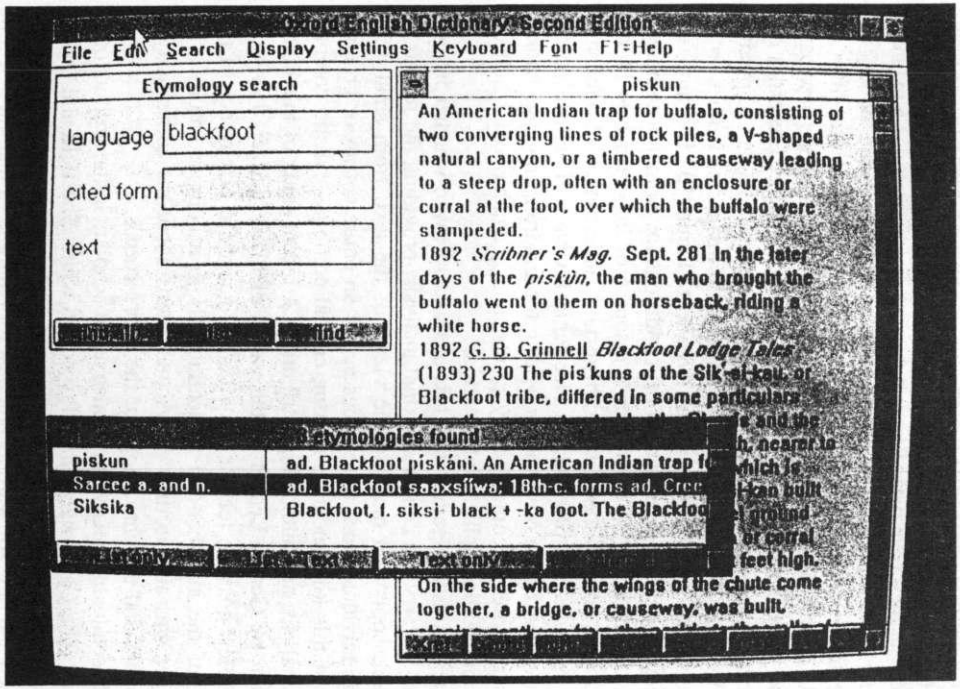

Figure 1 The etymological search for words in the *Oxford English Dictionary (Second Edition) on Compact Disc* coming to English from other languages is eased by the *OED* in electronic form. This figure shows a screen displaying the result of a search for the words of 'Blackfoot' origin - a North American Indian Language. The search revealed three words: 'piskin', 'Sacree'; and 'Siksika'. The dictionary entries for each can be accessed in full, in this case one entry is shown.

and etymologies. Researchers interested in etymology cand find all words derived form a particular language, such as that of the Blackfoot Indians. A search which combines date, author publication, or word will find specific quotations. Different types of searches can also be combined.

Machine-readable text offers further possibilities which have been realised in the concept of hypertext. Hypertext has become popular as a way of exploring and manipulating texts that is non-linear, non-numerical, and allows readers to discover and create their own paths through the material. It provides a means of linking together textual materials in an associative way by using 'nodes' and 'links', an electronic version of footnotes and cross-references. The links can be preserved to permit others to follow predefined paths or to define new paths. This technique is particularly suited to rference works. Project Electra, a collaboration between the universities of Manchester and Oxford, plans to produce an electronic resource base of women's writings and images of women in the period 1785-1815 and will make use of hypertext (Figure 2). The aim is to create a complex and dynamic picture of the conditions for women's authorship in the period, and in doing so to provide a resource of importance to literary scholars, historians, cultural theorists, art historians, and scholars of pubhshing history. Four modules are planned: an electronic textbase of female polemicists; an electronic textbase of women's writing for children; an image bank of female representations in contemporary prints; and a database of historical, biographical, and bibliographical information.

Electronic text is used together with text analysis software-whether integrated or separate-to carry out complex textual analysis, providing the researcher with both microscopic and macroscopic views of the text, from small-scale features of an individual work to searches across an entire corpus or group of works. Work of this kind includes making critical editions, stylistic comparisons, lexical analysis, and authorship attribution. A recent study of this kind is the examination by Gerard Ledger of the works of Plato (Ledger, 1989). By taking the simplest possible feature of written language-the occurrence of particular letters of the alphabet-and subjecting this to a complex multivariate analysis, Ledger was able to draw new conclusions about the authenticity of dubious dialogues and the chronology of the entire corpus.

Computer-based textual analysis can also assist scholars in the production of critical editions. The *Canterbury Tales* Project, in which Sheffield and Oxford Universities will collaborate, aims to draw upon the traditional methods of textual criticism and new software techniques, for example Collate (see Section 2.8, below), to reveal unseen patterns in the multiple manuscripts of Chaucer's *Canterbury Tales*. The main objective of the project is to produce a library of resources which can form the basis of critical editions of the *Tales,* language studies, and historical and cultural analysis. The manuscript tradition for the *Canterbury Tales* includes some eighty-three manuscripts, some of which are fragmentary, and although the *Tales* were well understood before the advent of

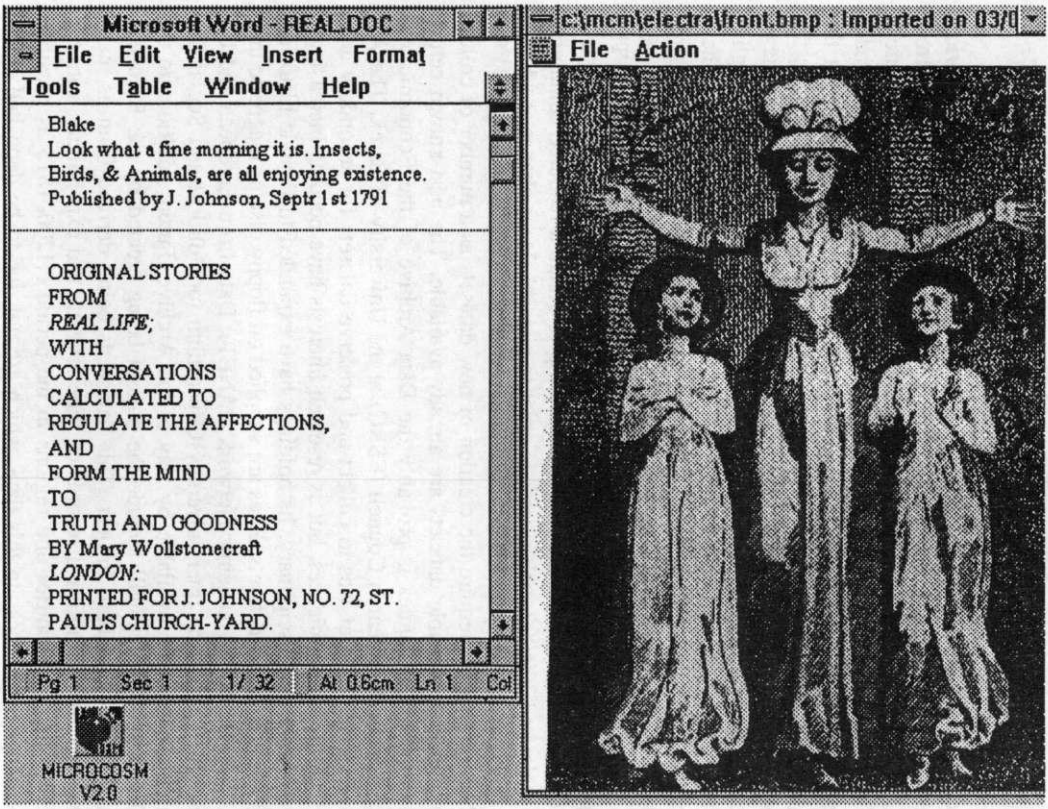

Figure 2 This sample screen shows the title page and frontispiece from a text included in Project Electra.

computer systems capable of handling significant quantities of data, study of the entire manuscript tradition was not feasible.

2.3 Data

The use of computers for handling data is well established in areas of historical and archaeological research which require the scholar to extract data from source material, formalise them, and organise them for analysis. In these areas the individual dataset, collected and organised for specific projects, is predominant. Some projects do rest on the analysis of textual information, but the majority of computer projects do not. For many studies structured data is the basic source. Historical scholarship often involves not merely the analysis of existing datasets, but also their creation. For example, registers kept by English bishops during the period from c.1260 to 1510 include ordination lists. These contain some biographical details of clerics, and a prosopography would provide a resource for studies of patronage and means of financial support, as well as studies of clerical origin and mobility during the late Middle Ages. The English Medieval Clergy Database project, based at Queen Mary and Westfleld College (University of London), is attempting to create a resource containing the estimated 300,000 such records in order to give scholars a chance to address these issues (Figure 3).

Not all projects require the creation of new datasets as a number of collective, machine-readable datasets are already available. The best-known centre holding these resources is probably the Data Archive of the Economic and Social Science Research Council (ESRC) at the University of Essex. The Archive's original brief was to collect and preserve datasets for secondary analysis in the social sciences, but as research interests have become increasingly diverse and interdisciplinary, its holdings have expanded to include historical and environmental datasets. Files are supplied on floppy disc or magnetic tape and over the Joint Academic Network (JANET). Data from European and US archives, such as the InterUniversity Consortium for Political and Social Research (ICPSR) are available by way of the Archive. Future additions to the ESRC Data Archive will include the dataset being created by the European State Finance Database Project. This dataset is being derived from as many published and unpublished records of state revenue and expenditure from the main European countries and regions in the period c. 1200-1815 as possible. The benefits of access to this data, which are not due to be deposited at the Archive until November 1993, have already been reflected in publications of the project contributors.

An important question for the providers of large datasets and archival material is how the database should be organised to facilitate access in the way users want. The automation of archive catalogues has led in some cases *to* a reconsideration of the way this material is designed and prepared. A free-text

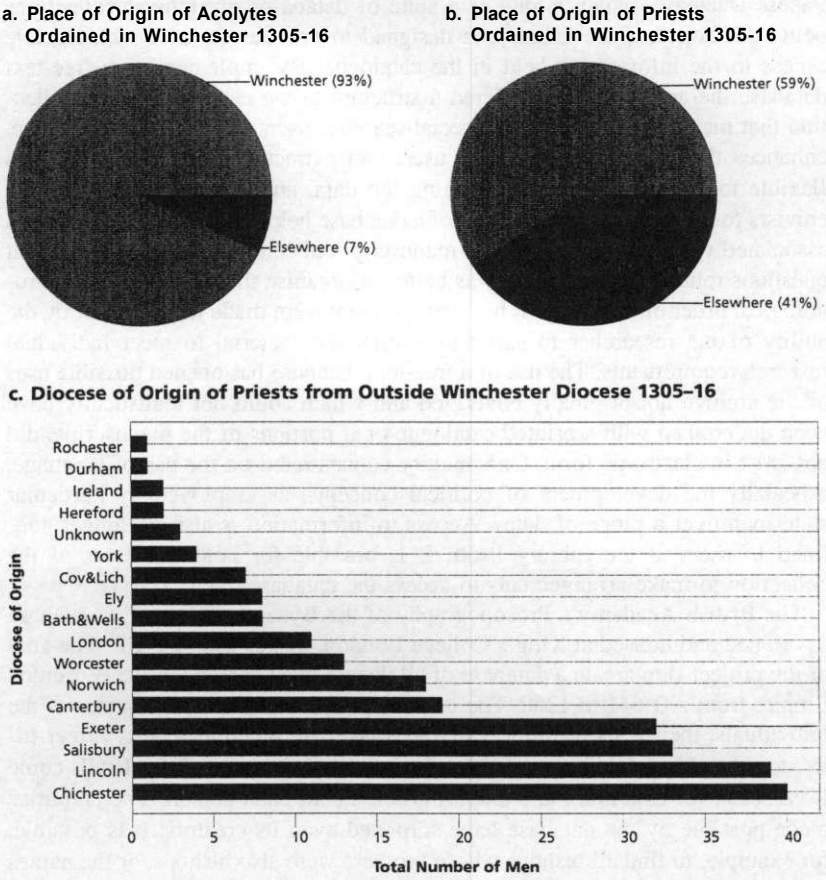

Figure 3 The ability to analyse data and present them in charts helps to make the information easier to explain. Clerical mobility in the early fourteenth century (a) shows the very small numbers of acolytes originating from outside the diocese of Winchester in the period 1305-16; (b) shows the numbers of priests originating from outside the diocese of Winchester in the same period; (c) is a detailed breakdown of the diocese of origin of the priests coming from outside the diocese.

retrieval system, STATUS, is being used to catalogue the papers of the first Duke of Wellington by archivists at Southampton University. The Wellington Papers Database, which is one of a suite of databases of archival collections being developed at the Library, is designed to provide the user with flexible access to the information held in the catalogue. By implementing a free-text database the archivists have offered a structure to the catalogue of the collection that maximises the types of special searches users can define and execute, enhances the potential information users can extract from the archive, gives flexible tools for searching and sorting the data, and is easy to use. The archivists found that the development of a database helped to resolve some issues associated with the ordering of the manuscript collection. They concluded that questions relating to whether it was better to organise the collection into chronological order or to arrange it by correspondent were made less relevant by the ability of the researcher to sort and reorder the material to meet individual research requirements. The use of a free-text database has opened possible uses of the archive not originally envisaged and which could not realistically have been undertaken with a printed catalogue or if portions of the manuscripts did not exist in electronic form. One enquiry concentrated on the use of language, especially the development of political concepts, as employed by particular statesmen over a range of dates. Access to information is also no longer confined to users at the Library itself; it is possible for potential users of the collection to make arrangements to access the database over JANET.

The British Academy's Prosopography of the Byzantine Empire, a database developed and housed at King's College London, makes use of TRIP. The goal of the project is to create a database of all documented persons in the Byzantine Empire from AD 641 to 1260. The information recorded includes names of the individuals, their responsibilities, first and last date mentioned, sex, career titles, topographical details, sources for the information (some of the details come from seals, for example), and a short article about each person. The enquiries made possible by the database have surprised even its creators; it is possible, for example, to find all bishops whose brothers were also bishops, or the names of all individuals who appeared at the court of a particular emperor, along with a host of details on religious sects, languages, and patrons. It is planned to make the database more generally available on-line or on CD-ROM. Scholars face major problems arranging distribution of, and long-term access to, their datasets. By widely distributing their data, however, scholars increase the likelihood that their research will be accessible to current and future scholars.

Some specialised datasets are now commercially available on optical storage media. One example is the CD-ROM version of the Eighteenth-Century Short Title Catalogue published by the British Library. Studying eighteenth-century history, literature, and culture in general gains, because it is possible not only to identify, from among the 305,000 records, the current location of printed material written by particular authors or having particular titles, but also to inve-

stigate where works were published in the eighteenth century and which printers handled which types of books. Other commercially published datasets will soon include the tithe surveys made following the Tithe Commutation Act of 1836 to be released on CD-ROM by Adam Matthew Publications. The database will be provided with searching software, allowing data to be selected, ordered, tabulated, and output. In this case the data have not been aggregated or ordered, but the tools are provided for researchers to perform their own manipulation.

In historical research, scholars who use computers usually create their own datasets. A large number of machine-readable historical datafllles have been created over the years; they are not only the product of historians, but encompass the whole spectrum of the humanities and social sciences-geographers, anthropologists, genealogists, family history groups, and sociologists. At present there is no Humanities Data Archive for such resources, an equivalent to the ESRC's Data Archive. A study of historical datafllles in machine-readable form undertaken by the Cambridge Group for the History of Population and Social Structure for the British Academy identified a large number of files, ranging from the small and simple (indexes and small census samples) to the large and complex (relational databases using multiple sources and a variety of data types). The findings of the survey have now been published and as a result of the study the ESRC Data Archive has started a History unit. This, however, only covers a small segment of the data created by humanists and there is certainly a need for a humanities information archive.

The discussion of data might leave the impression in the reader's mind that historians are the only humanists making use of databases. This would be misleading. Archaeologists, for example, are well-established database users with numerous local and national resources. The National Archaeological Record (NAR) can be accessed through an on-line database called NAR ONLINE. The NAR includes records of some 140,000 sites in England, English Heritage records for about 12,000 scheduled ancient monuments, and an increasing number of British Library derived records for bibliographic items. Over the next decade the database is to be extended to include many more sites, at the same time providing a national index to the more detailed information to be found in the archives of the Royal Commission on the Historical Monuments of England (RCHME). A more imminent change to the system will see it become the National Monuments Record as it is expanded to include, among other information, archaeological data. The British Archaeological Bibliography (BAB) sponsored by a consortium of British archaeological organisations is in the process of converting twenty-four volumes of British Archaeological Abstracts published between 1968 and 1991, containing nearly 25,000 publication references, into machine-readable form. Eventually this database will be accessible either over JANET or on CD-ROM. There are also regional projects. The Churches Committee of the Council for Scottish Archaeology, for instance, is completing an Inventory of Scottish Church Heritage that will soon be publis-

hed on CD-ROM. On a more local level there are under development numerous museum databases of different sizes and types, such as Leicestershire Museums Services, Manchester University Museum, Plymouth City Museums, and the work of many individual scholars and archaeological units is heavily dependent upon computerbased tools.

Scholars engaged in historical research make use of an increasingly wide range of software packages in order to assemble, organise, analyse, and display their source material. Statistical packages, which have been used for many years, have been joined by programs for relational database management, nominal record linkage, mapping, and hypermedia. Developments in software that allow data to be input in a way that preserves their complexity and irregularities facilitate source criticism which is fundamental to the historical study. A prosopographical project to create a databank of Italian Renaissance University Teachers and Students is making use of Κλειω (KLEIO), which is particularly suitable for historians who wish to process structurable data without losing the possibility of access to the original text (see Section 2.8, below).

A project to create a comprehensive Register of Musical Data in London Newspapers 1660-1800 is being undertaken at Royal Holloway and Bedford New College. The project, which is collecting structured and free-text data, makes use of Oracle's implementation of the Structured Query Language (SQL) and its free-text retrieval module. The project has completed collecting data for the period 1660-1720, an exercise that has produced a textbase containing some 15,468 entries. Work with this database has demonstrated that it opens new avenues of research to those studying music of the period. For example, the Project Director has shown that by using the resource it is now possible to examine questions about the economic and social aspects of music, to study the relationship between music and publishing, advertising and readership, and to investigate the role of musical activity in late seventeenth- and early eighteenth century English society. There is every possibility that when the entire register is complete it will be possible to study change in the role of music over time and look more broadly at the social and economic function of music.

The Port Books Programme, based at Wolverhampton University, is concerned with the study of the trade and material culture of pre-industrial England and Wales, and supports a diverse series of databases of free-text, structured, and statistical information. The programme of research embraces three discrete but complementary research projects: the Gloucester coastal Port Book database, 1576-1765; the trade of the Bristol Channel, 1691-1705 and associated databases; and the Dictionary of Traded Goods project, 1550-1800. The Dictionary project is concerned with the identification and analysis of the words and phrases describing the increased variety of goods and materials traded and makes use of relational database programs in order to handle this wide array of source material. These databases will serve as a resource to help improve the

historical understanding of the economic, social, and material culture of the period.

Visualisation of information has long been a valuable explanatory tool among historians and archaeologists. Computer mapping systems in general and geographical information systems in specific have dramatically improved the possible ways of generating presentations of this kind. Mapping London in the 1690s, a project being undertaken at the Centre for Metropolitan History, is designed to enable a critical examination of the social and economic structure of the metropolis at this period. Information has been gathered from a variety of sources to construct a database of 61,500 assessed taxpayers, the majority of whom were householders, and a dedicated mapping application developed by the Geography Department of University College London has been used to integrate quantitative and fiscal data with a sequence of digitised maps (Figure 4).

2.4 Images

Digital technology makes visual, textual, and numeric information both more accessible and easier to handle. Archaeologists, art historians, geographers, and historians are increasingly making use of the techniques of digital image processing, image enhancement, and graphics.

The rapidly developing field of computer graphics is beginning to play an active role in archaeological data processing. Such systems bring to archaeology new mechanisms for analysing data. By using graphical representations it is possible to explore a range of different configurations and interpretations of the evidence, allowing archaeologists a 'second look'. The Winchester Graphics System (WGS) from IBM UK's Scientific Centre, which combines a relational database and a threedimensional graphics system, was used to interpret the findings of an excavation at a late Bronze Age midden in the village of Potterne, Wiltshire. The system produced images showing the three-dimensional position of objects in the midden and assisted archaeological interpretation of the process of the site's deposition.

Computer modelling systems are also being used to build computer-based reconstructions of archaeological formations (Figure 5). Divided Object Raytrace Algorithm (DORA), a solidmodelling system developed by the School of Engineering at the University of Bath, was used to create a computer-based reconstruction of the temple precinct from Roman Bath. The pictures it generated allowed archaeologists to observe how the temple builders had made use of space to emphasise the symbolic relationships between the various structures in the precinct. The model itself provided a graphic illustration of the use of space as power and an insight into the Roman conception of the relationship between power and space.

In addition to three-dimensional analysis and sohd-modelling, images captured by digitising cameras or by digitising conventional photographs offer

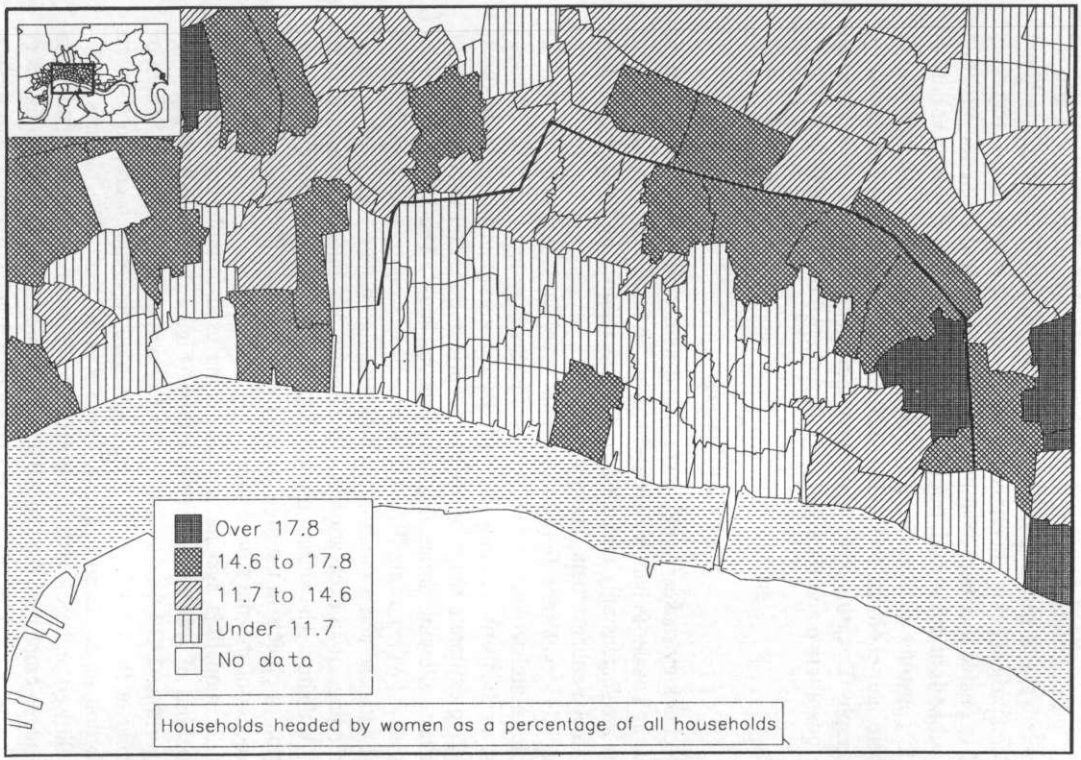

Figure 4 Households headed by women as a percentage of all households in the 1694 Four Shillings in the Pound Aid assessments. This is one of the numerous visualisations of data produced by the 'Mapping London in the 1690s' project.

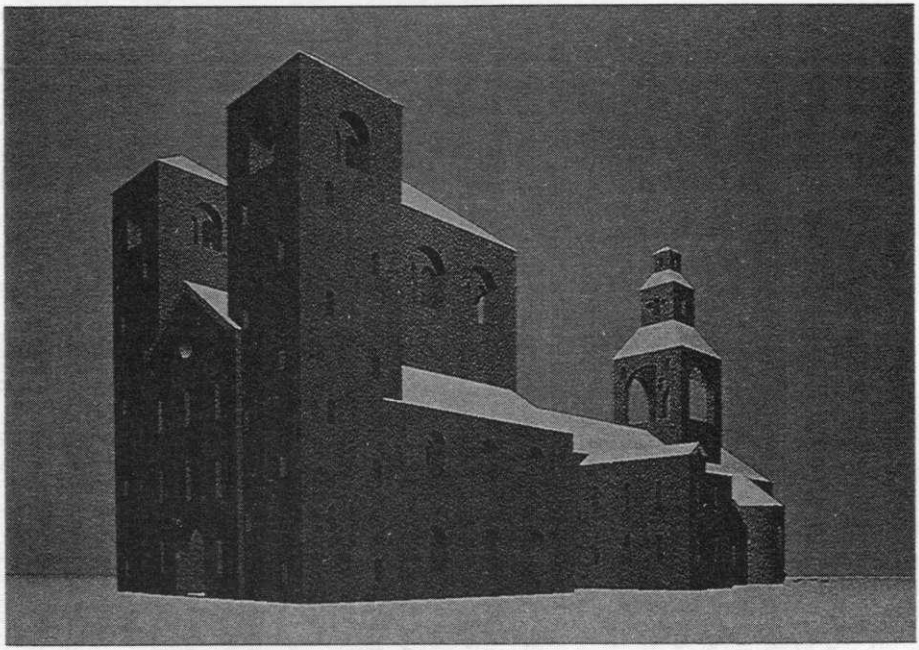

Figure 5 A solid image of the Old Minster, Winchester, created at the IBM UK Scientific Centre using the 'WIMSOM' Solid Modeller program. The solid model image offers scholars a new method of studying buildings, such as the Old Minster, which are known primarily from archaeological evidence or historical descriptions.

scholars new tools. Museums and art galleries have recognised digital technology as a way of providing enhanced access to their collections, and a number of computerised systems have been established either as permanent or temporary displays, including the Micro Gallery in the NationalGallery's Salisbury Wing and the Royal Museum of Scotland's Wealth of a Nation exhibition. The design of these applications and of other educational packages which make use of digitised images has been influenced by the realisation that users need to interact with the sources. A videodisc covering the World of the Vikings developed by the York Archaeological Trust, the National Museum of Denmark, and Past Forward (Figure 6), and the LIVE videodisc, produced at Leicester University, which contains 2,500 still photographs and eighteen minutes of motion video covering a variety of archaeological images, are two examples of educational applications.

The techniques of image storage and analysis developed in scientific disciplines, such as crystallography, astronomy, and medicine, clearly have potential for the humanities and experimentation is now yielding experience and methods that take advantage of these techniques. A means of recording high resolution digital images of works of art, although the complexity and expense of this approach place it beyond the reach of most institutions, was developed by the Visual Arts System for Archiving and Retrieving of Images (VASARI) project. Consideration of this project allowed the Panel to raise the important point that humanities applications can open fascinating computational problems that often challenge conventional computing and demand 'leading-edge' approaches and tools.

Images accompanied by textual (bibliographic, cataloguing, descriptive) data often represent the only way to provide flexible and dynamic access to collections. The Beazley Archive/Cast Gallery of the Ashmolean Museum will eventually provide a text and image database of ancient Athenian ceramics of the sixth, fifth, and fourth centuries BC. More than 50,000 text records are already available on-line from Oxford to researchers in Europe, North America, and Australia. Work has now started on scanning and digitising images from the Archive's 250,000 prints to accompany the textual records (Figure 7). Image transmission will exploit developments in telecommunications technology which support the efficient transmission of high resolution images. Trial transmission of images between Paris and Oxford has already been achieved on the public Integrated Services Digital Network (ISDN), making this project the first computerised database in the arts to reach this stage successfully. The availability of the Archive's text and image base to the international community and its multimedia educational project will require the SuperJANET fibre optic network, described below.

The Corpus of Romanesque Sculpture is one of the British Academy's major research projects. Its purpose is to photograph and catalogue the surviving heritage of sculpture, both religious and secular, in Britain and Ireland produ-

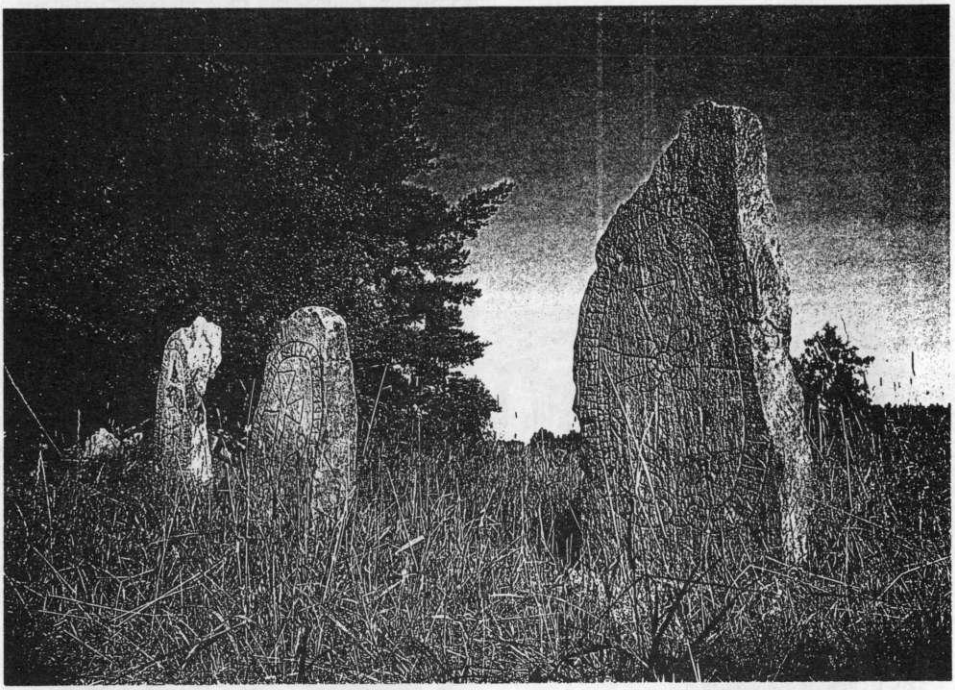

Figure 6 The inclusion of high-resolution images on CD-ROMs and videodiscs provides researchers with valuable tools for presentation and research. In this image Scandinavian runestones are depicted.

Figure 7 Two views of the 2nd century AD 'Varvakeion statuette' generally thought to be a small scale copy of the colossal gold and ivory cult statue of Athena by Pheidias which stood inside the Parthenon on the Acropolis of Athens. One of the images available from the distributed databases under the development by Beazley Archive/Cast Gallery of the Ashmolean Museum.

ced within the period c. 1066-1200. The objective is to achieve a computerised archive to which scholars will have direct access and which will also be capable of generating a variety of forms of publication, both conventional and electronic. The electronic archive, The Romanesque Sculpture Processor (RSP), provides access to the stored information in a number of different ways and gives users the ability to define their own special searches of the data. It supports the simultaneous and efficient display of text and multiple images and caters for high and consistent standards of reproduction in terms of image resolution. Users can search the database for categories of sculpture (e.g. linen-folded scalloped capitals), specific motifs, or sculptural features. The archive's text-base can be read sequentially or in a non-linear manner, as the text retrieval system allows users to follow particular kinds of information through the corpus as a whole. The computerisation of the project has been divided into logical stages. Thus, in the first, the Corpus has concentrated on the development of a single hardware platform that could only be accessed by scholars visiting the archive in person. Future access options could include local multi-user entry, telephone connections, wide-area networks (such as JANET), and distribution on optical and magnetic discs. Thereafter, as discrete segments (geographical areas, such as a single county, or a particular monument) are completed they could be made available for distribution as multimedia CD-ROMs. The Corpus is a dynamic entity and as the team of researchers gathers more information this text and image data will be added to the system. The complete database will contain an estimated 60,000 images and the equivalent of 15,000 pages of text.

The digitised image, combined with computer technology, offers the art historian the same kind of opportunity for retrieval and manipulation as that enjoyed by the classicist working with the *Thesaurus Linguae Graecae.* Most access to images is still via textual description of the image, but this is not necessarily the most useful way to search or manipulate them. The Morelli project, undertaken at Birkbeck College, demonstrates some of the possible advantages of working with digitised images (Figure 8). Programs manipulating digitised descriptive codes derived from existing art reproductions on a fairly modest computer can make accurate distinctions between information derived from what, to the human eye, seem similar images. But this is only one possible application, and a more useful function of the tool will be in the searching of archives of visual images to find similar and related compositions. This type of system offers possible applications in the areas of identifying, referencing, classifying, and analysing images. As hardware with large storage devices, faster processors, and enhanced resolution and graphics capabilities becomes more widely available, art historians will have a greater opportunity to perform research of this kind.

Researchers in the Classics Department of King's College London, supported by a grant from the Leverhulme Trust, are constructing a database combi-

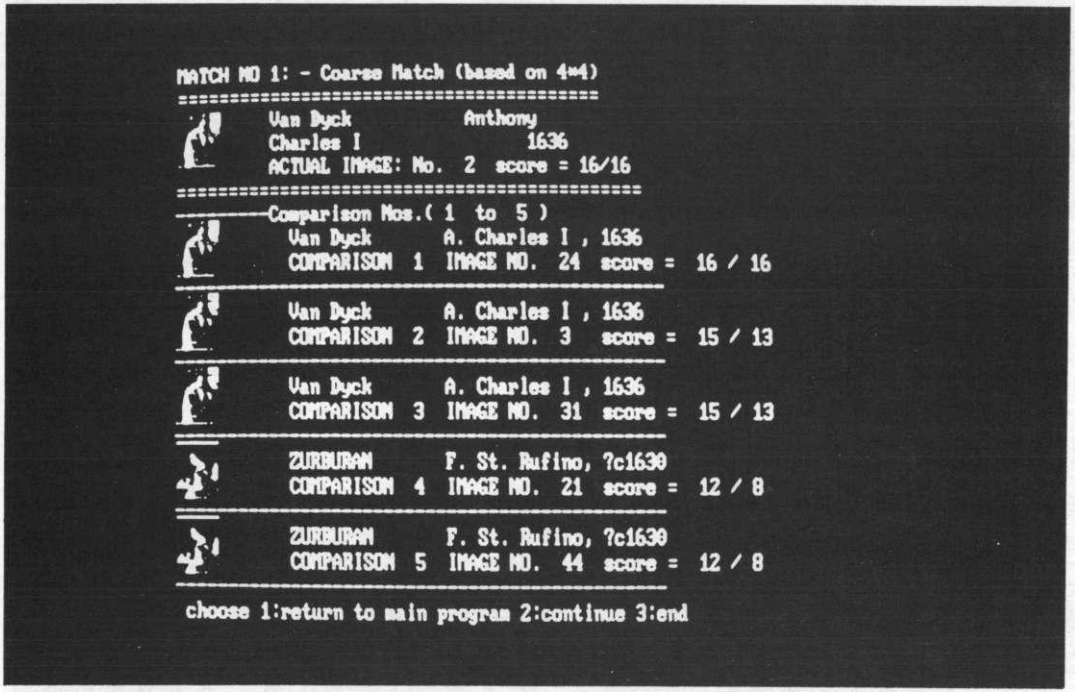

Figure 8 Example of the result of an automated search for related reproductions of a portrait of Charles I by Van Dyck using the Morelli system developed at Birkbeck College by Professor William Vaughan.

ning written discussion and visual images of all the textual, epigraphical, and material evidence relating to the life, work, and style of the known Greek sculptors from the Archaic to Hellenistic periods. The system, called DAEDALUS, allows any combination of words and images, including any two images, to be displayed simultaneously. The project, based in the Ashmole Archive, expects to release its results initially on CD-ROM. The resource will assist ancient historians, art historians, and classicists in their study of Greek art whether they are attempting to understand working practices of individual artists, the development of styles, or the socio-economic or political function of art in the Greek world.

2.5 Sound

Digitised sound, not unlike images and data, can be created, manipulated, and analysed by computer. Computers can be used to generate or modify musical signals and as a control device for electronic musical instruments. Electronically generated music, or electroacoustic music, revolves around the Musical Instrument Digital Interface (MIDI). Originally MIDI enabled electronic keyboards and their associated sound processors to interact in the studio or on the concert platform. Since then the standard's status as a protocol for information exchange has emerged through the development of computer software which allows performers to record and edit performances, and composers to build up complex pieces of music. Since MIDI files mainly contain information about sequences on peripheral devices, it is possible for sophisticated sequencing software to run on lowcost microcomputers. The Composer's Desktop Project (CDP), a collaborative venture whose members include representatives from the universities of York, Keele, and Huddersfleld, provides a comprehensive computer music workstation for the composer. Composers have access to tools to manipulate sound (e.g. create, edit, mix, process, filter) and can record their compositions to disc.

Performance of electroacoustic music rarely involves computation taking place on stage, although projects based at the Massachusetts Institute of Technology (MIT) in the US and Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in France are exploring this research avenue with the aid of artificial intelligence (AI) techniques. The goal of the MIT project is to produce what may be called an automatic accompanying machine. In a live performance a human performer can respond to the computer's output, but the computer cannot reciprocate. For the computer to embody the characteristics of a performing musician it must be able to analyse sound into coherent and discrete pitches of determinate duration and spectrum (timbre), and then use that interpretation of the acoustic signal as a basis for interpreting a musical signal. It must take cognisance of cues as to segmentation-structure and generate a plausible model of what the live performer is doing, and then use this

information to structure its own performance. To build such a machine requires an understanding of the psychoacoustical and psychological processes involved in listening to and performing music. The MIT team has had to incorporate some 'engineering', rather than cognitive, solutions in the system which indicates the limitations of present understanding of the cognitive processes underlying musical perception and performance.

Music cognition is the subject of a project, which also makes use of AI concepts, currently being undertaken at the Faculty of Music in Cambridge in collaboration with researchers at the University of Liège. The project investigates how listeners represent short pieces of tonal music in cognition, and then attempts to produce a computer model of such representation. Researchers have conducted a comprehensive experimental programme, relying heavily on computers to control and generate musical stimuli, and have found that both musicians and non-musicians form fairly similar cognitive representations, incorporating a hierarchical structure. They are currently replicating and extending these experimental findings and producing plausible computational accounts of the processes that are observable in the results of the experiments. The finding that subjects' representations are in some way hierarchical is a validation of several recent theories of music cognition and demonstrates some of the similarities between music cognition and language cognition.

Improved storage techniques are offering new ways of presenting spoken archives and corpora. Collections of recorded speech were commonly transcribed and preserved as a text resource, but digital compression techniques and hypertext are now being used to store and access both transcribed and recorded speech. The International Corpus of English (ICE) project aims to establish a corpus of spoken and written English, and national data collection projects are now underway in all English-speaking countries. It is intended to make the speech recordings themselves available in compressed form on electronic media, such as CDROM. Hypermedia techniques will be used to link the transcribed and audible British material, and there are plans to link in video source material as well. The Machine-Readable Spoken English Corpus (MARSEC), now a collaborative project between researchers at the University of Leeds and Lancaster University, also stores samples of spoken English on CD-ROM. In addition to the speech, the discs will carry orthographic text, prosodie and segmental analyses, and continuous analysis of fundamental frequency.

2.6 Combined sources

Hypermedia systems (also known as 'multimedia') use hypertext techniques to incorporate other media besides text—images, graphics, animation, sound, and video. Information linked in this way becomes a flexible reference tool, effectively functioning as an automated encyclopaedia, but with the advantage of using computer-supported links to give visual proximity to conceptual connec-

tions. Hypermedia systems are interactive, allowing users to find their own path through the material, and they have obvious potential for both research and learning.

One of the best established hypermedia products was developed in the US and is now commercially available in this country. Perseus, a hypermedia database designed to aid the study of archaic and classical Greece, expands the ways in which ancient Greek literature, history, art, and archaeology can be investigated. As well as complete literary texts, Perseus contains a lexicon, morphological databases, an extensive archaeological catalogue with accompanying illustrations, an atlas, site plans, an illustrated catalogue of Greek vases, a classical encyclopaedia, and an historical overview of the history of the classical period.

In the UK the Renaissance Project, a collaborative venture between Apple Computer and several higher education institutions, was established to investigate design and development tools for interactive multimedia learning and to produce multimedia products. One of the products developed, Shakespeare's *Twelfth Night or What you Will,* takes users through the topics of Shakespeare's life, Elizabethan society, the Renaissance theatre, and the Theatre of Memory. The user can choose between a spoken guided tour of a topic or individual selective browsing.

Music is a natural subject for multimedia, and several commercial products have appeared; these are CD-ROM guides to individual works. The Music Consortium, supported by a grant from the Teaching and Learning Technology Programme (TLTP), which is being co-ordinated at Lancaster University, intends to produce courseware designed to run on Apple Macintosh computers and under Microsoft Windows on PC compatibles. The courseware, to be distributed on CD-ROM and floppy disc, will focus on the development of basic musical skills, methods of musicological study, and tools to deliver basic information on core repertoires of Western music.

Hypermedia is becoming established as a powerful teaching tool and several initiatives are underway to develop both software and expertise in this area. The Software for the Teaching of English Language and Literature and its Assessment (STELLA) project was set up at Glasgow University to develop software for teaching, and several useful packages have been produced dealing with Old English, Old Icelandic, analysis of *Piers Plowman*, modern English grammar, and writing techniques. The Hypermedia in Language and Literature Subjects project is funded by the Information Technology Training Initiative and although based at Oxford is supported by academics from a number of other institutions. One of its projects is to produce a package to teach the basics of English phonetics.

The Hartlib Papers Project presents perhaps the best example of the concept and application of hypermedia techniques for text management. The project was established in 1987 at Sheffield University to study, edit, and make ac-

cessible the surviving papers of Samuel Hartlib, comprising about 20,000 pages of seventeenth-century manuscripts. Hartlib and his collaborators believed in the interrelation of all knowledge and the Project Director has argued that the papers constitute a consciously developed 'database', designed to collect and disseminate information on all subjects which contributed to the betterment of mankind through education, science, politics, philosophy, and religion. Quite apart from the words on the page, the Papers themselves, as objects, are rich in information, containing drawings and diagrams, editorial markings, original seals and addresses, as well as examples of seventeenth-century handwriting. It was felt that traditional research methods failed to derive maximum benefit from this remarkable archive and that conventional publication could not do justice to the original documents. The British Academy and the Leverhulme Trust funded the project in the hope that this hitherto impenetrable archive could be made accessible to scholars in a way that would preserve its sense of interconnection and would avoid the imposition of twentieth-century disciplinary and subject divisions. The total collection has been transcribed; as the first phase of the project the transcriptions, translations, and interpretations of the Hartlib Papers have been made available as an on-line database. The essential nature of the Archive is particularly suited to hypermedia wiht its capacity for interlinking documents and images, and this is the chosen medium for the final electronic edition of the Papers. The electronic edition of the Archive will offer the dynamic environment necessary to bring alive Hartlib's ideals on the integration and dissemination of knowledge and it will offer scholars the opportunity to investigate the material in the archive rapidly, exhaustively, and precisely.

2.7 Electronic communication

Developments in communications technologies and facilities have had a significant effect on the way scholars use and exchange information. JANET was established more than ten years ago to provide a network for the British higher education community. Since then its use has grown dramatically. Now it is used not only for messaging, electronic mail, and day-to-day communication, but also for the exchange of papers, for collaborative ventures, and for access to resources. In this context it is important to emphasise that the effective use of electronic mail (e-mail) and on-line information services requires adequate access-a personal computer or intelligent terminal on every scholar's desk. In humanities departments such provision is by no means assured. A survey conducted by the Office for Humanities Communication (Mullings, 1992) found that only 34 per cent of questionnaire respondents had access to e-mail. Improved access is essential to ensure that the growing number of services, including those described here, are available to all scholars.

The use of e-mail has led to the formation of discussion lists and bulletin boards. Discussion lists allow users to exchange ideas, problems, and requests

with other scholars. Bulletin boards include information that is 'posted' and users log in to read what interests them. The Humanities Bulletin Board (HUMBUL) is operated by the Office for Humanities Communication and has about 5,000 registered users. Other bulletin boards of interest are the Bulletin Board for Libraries (BUBL) and the National Information on Software and Services (NISS) which provides information on software for all subjects. Besides these general services, there are also specialist bulletin boards and discussion lists. PHILOS-L, based at Liverpool, was intended primarily for distribution of information about jobs, conferences, and the occasional query, but its users report that it often hosts lively scholarly debates. The Archaeology List (ARCH-L), run from the Gesellschaft für Wissenschaftliche Datenverarbeitung mbH at Göttingen, is a discussion list for archaeologists and also acts as a distribution service for data and software. It supersedes the Archaeological Information Exchange (AIE) run from Southampton. Numerous other discussion lists are available, but in the humanities they are used by few scholars because of an apparent lack of facilities to access the network on a regular basis. Networked information can be much richer than just discussion lists and bulletin boards. The Council for British Archaeology (CBA) is in the process of setting up a British Archaeological Information Service, which will provide archaeological data such as fact-sheets, articles, and bibliographic resources.

JANET provides on-line access to electronic archives, automated library catalogues, and numerous information services. The British Library's Automated Information Service (BLAISE), covering the vast resources of the British Library, the US Library of Congress, government publications distributed by Her Majesty's Stationery Office, and several other databases, is available to academic researchers via JANET. The ISI Arts and Humanities Search database is now similarly accessible, thanks to an agreement between the Combined Higher Education Software Team (CHEST) and the Institute of Scientific Information (ISI). Arts and Humanities Search is the machine-readable version of the printed *Arts and Humanities Citation Index,* which indexes over 1,300 journals worldwide and provides multi-disciplinary coverage.

In 1991 Internet, which is a 'network of networks' connecting different networks by means of a common communications protocol-the Internet Protocol (IP)-became accessible to JANET. The connection to Internet has presented great opportunities. On-line library catalogues, databases, and information services are now accessible to scholars on a worldwide basis: the World Bank's Socio-Economic Data, Dartmouth College's Dante Database, and the Israeli Bibliography of Antisemitism are just a few examples. Resources, from large data files to free software packages, can also be exchanged using the File Transfer Protocol (FTP). As more and more institutions gain access to Internet, the number of information sources open to scholars will expand enormously, giving rise to the concept of the 'virtual library'.

Work is underway on SuperJANET, a new optical fibre network which will be a thousand times faster than the JANET network. An initial six sites are

being connected early in 1993 and it is hoped that eventually all higher education institutions and government-funded research establishments will be linked. This new broadband high-speed network will offer the capacity for innovative information services. A study being undertaken at Heriot-Watt University into the potential of SuperJANET for library and information services has identified five areas, all of great significance to humanities scholars: new publishing opportunities; the possibility of a national, real-time, digitised document delivery service; the capability of carrying pictures and sound, thus providing access to picture and slide collections and to sound archives; the scanning and delivery of high-quality facsimiles of manuscripts, archives, and rare books; and the delivery of multi-media courseware and interactive learning sessions.

2.8 Tools

A remarkable amount of commercial software is currently available; some serves the needs of scholars, but not all their requirements are met. Although a critical appraisal of software would be of value, the number of available packages and the diversity of their application areas made this a task beyond the scope of the Panel. The Panel did observe that there was a need to keep humanists informed about software that might better meet the demands of their research (see for example Davis, et al. (1992), Lancashire (1990), Spaeth (1991)). Some tools for handling text, data, and images are available as commercial software packages and can easily be tailored to support a range of humanities research projects. The comparatively powerful facilities for freetext search of programs such as BRS/ Search are proving useful in many areas, including literary and linguistic scholarship. Idealist, a freetext database manager, is popular among historians. Similarly, there are many database packages on the market-dBase is very widely used, for example. Many historical applications demand the power of relational databases to handle the complex interrelation of the data. A recognised standard language for relational databases, the Structured Query Language (SQL), features in relational database management systems such as INGRES and ORACLE. Numerical analysis was one of the first applications of computers in historical and archaeological research; the Statistical Package for the Social Sciences (SPSS) continues to be widely used and is well supported by computing services; microcomputer versions are now also available. A wide variety of modelling and graphical packages are also in use, some of which, such as ARC/Info, integrate advanced mapping with relational database facilities. Commercial software, even when it can be tailored, does not meet all the needs of scholars and in some cases it is important to write special software for humanities applications.

Software packages are being developed from within the academic community which are specifically geared to the needs of humanities researchers. The

International Corpus of English has developed a Corpus Utility Program (ICE-CUP) to aid the study of large corpora. Archaeologists at Bradford University have implemented a computer system for rectifying oblique aerial photographs (AERIAL), and at the Institute of Archaeology, University College London, archaeologists have developed a program to assist in the statistical analysis of ceramic assemblages (Pie-slice). In some cases the impact of specialised software has been limited to meeting the needs of a small number of scholars or a specific project, but in other cases the impact has not been so limited. The pioneering software system Κλειω (KLEIO), developed by Dr Manfred Thaller of the Max-Planck-Institut at Göttingen, has revolutionised historical computing in the German-speaking world. Starting with the principle of 'source-oriented data processing', Κλειω provides historians with a range of sophisticated, discipline-specific tools. These enable historians to preserve the integrity of their source material while handling that material in a wide variety of ways. To this end, Κλειω offers powerful text handling facilities, routines for dealing with varieties of historical dating systems and matching algorithms, the handling of fuzzy and contextsensitive data, image retrieval and information exchange. The approach has been accurately defined as that of the 'historical workstation'. Κλειω is currently being translated into English and this should encourage its adoption outside the Germanspeaking world.

Researchers use text handling software with electronic texts to carry out complex textual analysis that otherwise would be tedious and time-consuming, if attempted manually. Many such packages are now available to scholars. One of the best known is the Oxford Concordance Program (OCP). It was originally developed for mainframe computers, but a PC version-Micro-OCP-is now available. OCP is a general purpose tool for text analysis and is suitable for applications such as stylistic analysis, preparation of language courses, morphology, vocabulary acquisition, dictionary making, textual editing, and content analysis. It is widely used in literary research and also has applications in other disciplines, such as history, where textual analysis is required.

Investigation of manuscript traditions and the creation of critical editions from multiple manuscript sources require specialised software. Collate, a program developed by the Computers and Manuscripts project at the Oxford University Computing Services, helps scholars collate up to a hundred texts simultaneously; it provides facilities for adjustments of the collation by the user and it can generate output in many different formats, including several recommended by the Text Encoding Initiative (TEI).

The exchange of textual information poses problems. Some of these can be alleviated by the use of standard conventions. Many electronic texts are now encoded using the Standard Generalized Mark-up Language (SGML), which is the International Standards Organization (ISO) standard for the description of electronic documents. Before the acceptance of this standard, electronic texts were often encoded using idiosyncratic systems, which meant that while they

may have suited an individual scholar's purpose, they could not be used in any other way. The pace of conversion of text to electronic form has accelerated rapidly, and the Text Encoding Initiative was established in order to address the problem of a proliferation of differently encoded texts. The objective of this international project is to develop guidelines for the preparation and interchange of machine-readable texts for scholarly research. The first Guidelines, produced in 1990, suggested that SGML be adopted by scholars for the encoding of electronic text. SGML is a metalanguage which provides a syntactic framework within which mark-up or encoding tags can be defined, adding only those characters which can be transmitted over networks and can be read by most computers. The application of SGML is not limited to textual resources and its use can be extended to other disciplines; for instance, it is already used for the encoding of music. If these standards gain general acceptance the encoding of new data and the interchange of existing data will be revolutionised.

SGML encoding has enabled a new generation of text handling software to be developed. DynaText, which makes use of the SGML mark-up to provide sophisticated textual analysis and manipulation, is typical of these recent products. The DynaText system accepts SGML encoded text directly and creates electronic texts, automatically building a full text index and establishing hypertext links for tables, figures, footnotes, and cross-references. A browsing facility allows users to read, query, and annotate the text, and full-text searching is also supported. Style sheets use the SGML tagging to define the format for display on screen or for the printed document. This system is not without its limitations, and primary among these, as far as humanists are concerned, is cost. Many of the most powerful and advantageous software tools are priced far beyond the resources available to scholars, even when generous educational discounts are provided.

A number of simple-to-use hypertext authoring systems are now available, such as HyperCard from Apple, which teachers are using to compile their own hypertext courseware. Authoring tools which offer a 'shell' for the production of multimedia materials are also widely used. Guide, from Office Workstations Ltd (OWL), and Toolbook (Asymetrix) have been used successfully for a variety of multimedia applications. Advanced authoring tools have also been developed. Microcosm, developed at the University of Southampton, is an open hypermedia system with a generic linking facility which allows the integration of other applications such as Guide. Microcosm is being used by a number of humanities projects to link diverse materials—the Electra project, for example. The Winchester History Project at King Alfred's College, which aims to extend archaeological and historical studies of Winchester to the present day, providing an overview of almost a thousand years of urban history, also uses Microcosm. It has enabled the project to make a stimulating presentation of materials, including photographs, plans, diagrams, moving images, and oral history. Besides offering a variety of interactive display types, Microcosm has

been used by the project to give researchers access to the project's database. The project will use the database to study the development of Winchester, while other scholars might use the material to gather specific examples to illuminate issues in urban history.

2.9 Summary and outlook

This survey indicates that much research is underway and it involves the creation of new resources, the conversion of conventional sources into machine-readable form, and the analysis of material to answer scholarly questions. A casual glance at the projects shows that computers serve different roles at different stages in the process of research. The current model of raw materials of scholarship followed here includes text, data, sound, and images, but there has been a growing attention by humanists to the use of computers to model knowledge (Ennals and Gardin, 1990). Expert systems, programs which can be used to model knowledge, are being used by some researchers along with other artificial intelligence techniques (e.g. neural networks) to formalise knowledge and automate the process of interpretation. While projects in this area have generated lively debate, few have so far produced scholarly results, but they do show promise and are likely to produce results in the next decade.

Section 3

New developments and change

Some critics of computing in the humanities have pointed to the misplaced optimism of enthusiasts and to the dangers inherent in an uncritical approach. Fears have been expressed that resources will be diverted from more conventional scholarship and that research will be undertaken, not for its intellectual value, but because it lends itself to the use of computers. Not all forms of research are likely to benefit equally from new technology and some will benefit only through word processing and access to networked bibliographies. Nevertheless, the academic acceptability of computer-based research has grown steadily over the years. Some genuine scholarship has resulted from the use of computers by humanists; for example, J. F. Burrows, in a seminal study (1987), showed how Jane Austen made skilful use of common words to build up distinctive idiolects for the different persons in her novels in order to establish and even accentuate the individual characters.

Less well recognised is the intellectual effort required to design and create sets of machine-readable data. In historical research, for example, the data extracted from archival material must be collected, structured, and captured

before it can be analysed; transformation of the source material into a database requires deep understanding of its structure and nature and this constitutes a major intellectual achievement. Good illustrations of this include the electronic version of the Hartlib Papers and the Prospography of the Byzantine Empire. Moreover, the design of teaching tools poses major conceptual problems, requiring attention not only to scholarly and pedagogical content, but also to the form of presentation and its likely psychological impact.

Innovative tools and resources now available encourage new kinds of research. The electronic edition of the Hartlib Papers will allow scholars to explore this material in ways not possible with the paper archive. Similar kinds of benefits can be gained from study of the database of the Prosopography of the Byzantine Empire; answers to questions that would take hundreds of hours, if not months, to obtain if asked of the prosopography of the later Roman Empire using the published sources, can be provided for the Byzantine period in seconds. The computer graphics techniques used by some archaeologists are beginning to have a profound effect on the ways in which they represent and analyse the data they record. They will eventually affect every field of archaeological enquiry from survey, excavation, and analysis to reconstruction, synthesis, and communication.

Until recently, it has been difficult to find many unequivocal examples of scholarly research that could not have been achieved without the aid of a computer. This is changing, as the examples of the work of Burrows (1987) and Ledger (1989) make evident The emphasis in humanities computing has been geared towards the production of scholarly resources; interest is now shifting towards how these resources are used and the new sorts of scholarship that can be undertaken with them. The use of computers does not compensate for poor training, limited knowledge, and weak critical judgement. The computer is best seen as a researcher's assistant. As such, new technology is beginning to influence both research and teaching in a variety of ways.

Under the impact of new technology, the traditional image of the humanities scholar is beginning to change. National and international links provided by JANET give scholars access to bibliographies, discussion lists, electronic journals, and bulletin boards. These are fostering the development of a genuinely international community of scholars in the humanities. Recent years have seen the emergence of a new style of team-based research in the humanities, in part the result ofthese developments. This trend, if it continues, will require new thinking on the part of institutions and funding agencies.

A common interest in the use of computers is drawing scholars together across the boundaries between disciplines and subdisciplines within the humanities. There is an increased understanding by scientists and humanists of each other's methods and preoccupations. This trend has also served to make interdisciplinary work easier, as can be seen in the examples described above of collaboration of scientists and engineers with archaeologists and musicologists.

The use of computers also changes the way humanists think about and organise their research. Computers ease the ordinary, time-consuming tasks associated with research. Improved access to data held at scattered remote sites and the mechanical ability to manipulate large quantities of these data very swiftly offer the scholar the time and assistance to become more of a thinker than a searcher. The introduction of computers into the research process has opened up both new and unanticipated areas for investigation which demand new ways of thinking. One of the-perhaps unforeseen-values of computers is in making explicit what has been done intuitively; the preparation of data in a logical, formalised manner is an intellectually informative task and, if successful, can reveal types of evidence and questions for research that would not otherwise have occurred. At the same time, systems are being developed which are particularly suited to the way humanists have always thought and worked; hypermedia and hypertext provide an enhanced form of the browsing and cross-referencing facilities which are demanded by researchers.

This may be one reason why hypermedia authoring tools are already becoming popular in the humanities for the creation of courseware. The use of such systems in teaching is beginning to blur the distinction between teaching and research. This distinction will become progressively less clear-cut as students are encouraged to explore source material held in electronic form, previously available only to their teachers, and as the adoption of electronic aids in teaching encourages their use in research. Indeed, the introduction of computers into humanities teaching tends to encourage a redefinition of teaching itself and to shift the emphasis towards the learning part of the process. In this respect the Computers in Teaching Initiative (CTI) Centres are playing a leading role; their work is discussed in Section 4.

While pointing to the advantages offered by computers, the Panel felt it worth noting that the provision of an adequate level of equipment, training, and computing support did not justify the reduction of library and secretarial staff. Wellfounded concern was expressed that humanists who used computers were spending more time on mundane tasks, such as word processing and even desktop publishing, than they had in the past. It would be a great pity if the increased 'time for scholarship' that the computers can offer was consumed by tasks for which secretarial support had always been provided.

Section 4

To challenge and invigorate future scholarship

4.1 Introduction

Two-thirds of this survey are about computer-based humanities projects and it might appear as though humanists are starting off well in computer-based research. However, many of these projects are run on a shoestring budget, with directors carrying begging bowls and staff on short-term contracts. Others which are just starting, such as *The Canterbury Tales Project* or Electra, have found it astonishingly difficult to find funds, although many are technologically innovative, intellectually challenging, and will provide valuable resources and solid scholarly results. The projects described in Section 2 concentrate, of necessity, on 'leading-edge' developments in computing and the humanities. If these are to become the norm in the humanities then action will be needed to overcome a number of barriers: institutional, organisational, material, and personal. Information technology concerns not only the provision of skills and equipment but also changes in attitudes and working practices. Dramatic growth in the levels of funding, organisation of the distribution of resources to assure broad coverage, and positive encouragement of an information-rich scholarly community are essential.

4.2 Training and support

Adequate training and the provision of essential backup and support services are keys to the successful implementation of new technology. The lack of adequate understanding of available resources and shortcomings in the necessary skills to exploit them are major factors precluding the more effective use of information among researchers, teachers, and students in the humanities. In an attempt to redress this balance, the then Computer Board for Universities and Research Councils (currently the Information Systems Committee (ISC)) established the Computers in Teaching Initiative (CTI) which, in its first phase, instigated 139 projects, covering almost all disciplines. The programme sought to provide software and raise awareness of the potential uses of computers in university teaching. In the second phase of the initiative a national network of subject information centres has been established to offer advice and guidance on using computers in teaching. Five centres serve the humanities: the CTI Centres for History with Archaeology and Art History, Modern Languages, Music, Textual Studies, and Library Studies. The dissemination *of information* on all aspects of computing is central to its successful integration into huma-

nities departments. The ISC's Information Technology Training Initiative (some ITTI projects were described above) and the Teaching and Learning Technology Programme (TLTP) will complement the work of the CTI Centres. These centres provide essential advice and direction for humanities researchers, but whether they will continue to be funded after mid-1994 is unknown. It is also unfortunate that of the forty-three funded TLTP applications only five were for humanities projects.

The development and provision of a wide range of training opportunities for teachers and researchers in the humanities to promote the use of IT is a long-term requirement. However, the work of the CTI has highlighted a basic and pervasive problem of insufficient access to equipment and services in humanities departments. The implementation of the wide-ranging recommendations of the Working Party of the Committee of Scottish University Principals on *Teaching and Learning in an Expanding Higher Education System* could not fail to have a major impact on the computing skills of scholars in the humanities and hence on the application of information technology in research in these fields.

4.3 Network access and equipment

As noted in the previous section, humanities scholars are making increasing use of JANET and the information services available over this network. Very considerable benefits have accrued from the NISS and CHEST initiatives as well as the facility for searching the ISI databases. Many developments in humanities information are closely linked to the maintenance of the academic network; it would be of enormous benefit if access were extended to include libraries, museums, archives, and research institutes. The problem faced by archaeology appears to be typical of difficulties facing scholars in other disciplines. The reason why discussion lists and e-mail are not used heavily is that most archaeologists either do not reside in institutions that are connected to JANET, working by and large in archaeological units and museums, or, if their institution is connected to JANET, they are either not computer users or do not have access to suitable equipment. In some instances the problem lies with the lack of access to the local institution's network by departments or individual scholars.

At an institutional level many humanists have considerable difficulties in gaining access to even the most basic computing resources. There is a variety of reasons for this, including competition for funding, lack of ancillary support, and internal procurement policies. Humanities scholars recognise that they are often less adept at specifying their precise requirements for information technology than their peers in the science and engineering faculties and this is sometimes compounded by an institutional culture that ranks humanities low in the provision of computer and communications equipment. There appears to be

a cycle of 'low expectation, low allocation' in humanities departments, with the result that equipment needs are overlooked. At the same time researchers in the humanities frequently lack ancillary support of the kind routinely expected by scientists. Humanities projects, such as the VASARI Project, the current stage of the Beazley Archive project, and the studies of music cognition at Cambridge, are computationally demanding and technologically challenging whether this is in the areas of hardware, peripheral devices, or software design and integration. The humanities community must communicate to both local and national funders the fact that computing is now part of the everyday needs of humanities researchers and that these needs must be met.

4.4 Research infrastructure

In articulating their needs nationally, humanities scholars are hindered by the absence of any research council for the humanities and this has implications for funding as well as promoting research and research requirements. The British Academy and the British Library Research and Development Department play a key role in the promotion of research into humanities information. However, the BLR&DD is not treated on a par with the five research councils in terms of funding, and this has potentially serious implications for the buying power of its research budget. The British Academy is the principal source, after universities' general block grant funds, of finance for research in the humanities. Its current funding structure is affected not only by increasing financial constraint, but also by the lack of a committee analogous to the ESRC's Research Resources Division (RRD). As a result, proposals which are concerned with the collection, preparation, or management of information resources are not easily accommodated. In this context, collaboration between the British Academy, the BLR&DD, and other interested parties would help to ensure the development of information resources across the humanities by the acquisition of data, methodological research, and support activities. In this respect, the joint sponsorship by these two bodies of the Humanities Information Review Panel can be seen as a timely initiative.

At the same time a cultural change within the humanities itself is needed. Electronic publishing, and especially publication on networks, is one area that can benefit from a change in attitude, and it appears that it has not taken off in the humanities (or anywhere for that matter) for a variety of complex reasons: problems with refereeing; lack of standards governing the citation of electronic publications; the fact that electronic documents appear to have an ephemeral character; difficulties of access; and fundamental questions in the minds of academics on what constitutes a publication and what it means to be published. There is a slow growth in the numbers of electronic journals, but they have not achieved the academic credibility of their printed counterparts. In the area of publications on CD-ROM it is already apparent that the barriers to acceptance

of this as a media of publication have begun to break down. As the provision of and access to information on CDROM becomes more general, objections to publication in other electronic media are likely to disappear.

4.5 Information resources

Humanists depend to a very considerable extent upon libraries, both in their own and other institutions, and upon a network of museums, galleries, and archives. There is much evidence to suggest that library resources are diminishing as a result of attrition of their budgets, rising numbers and costs of traditional publications, the need to adopt strategies to conserve the printed books from the nineteenth and early twentieth centuries, the introduction of automated catalogues, and the need to purchase new electronic resources and in some cases the equipment to make them accessible to library users. At the same time the growth of new ways of accessing information, from Online Public Access Catalogues (OPACs) to CD-ROMs and online searching, has raised users' expectations of their resources. Consequently research libraries are now experiencing considerable difficulties in striking an appropriate balance between expenditure on traditional and novel forms of providing information in a time of budgetary restraint.

The discussions currently taking place under the aegis of the HEFCE/W Libraries Review are highly relevant. The initiative aims to assess the needs of the higher education sector for library provision in both its teaching and research activities. The Libraries Review will examine the changing demand of disciplines with special focus on the humanities and social sciences. The role that information technology can play in helping meet these needs has been singled out for particular attention by the Review. This and the related ISC Libraries Initiative are likely to play an important part in shaping the future provision of information resources in the humanities. A further initiative that could do much to improve the supply of datasets in electronic form is the recent establishment of a Datasets Inter-Agency Group (DIAG).

The growing number of projects creating electronic resources and the increase in those wanting access to information electronically held has highlighted the fact that no agency has taken an active role in fostering the growth of a national electronic archive for the humanities, analogous to the ESRC Data Archive for the Social Sciences. A national strategy is required for the holding, maintenance9 and provision of access to such material. There is also a need for funding to secure the conversion of information into electronic form, and since many sources are of national and international significance, attempts should be made to support collaborative efforts to create electronic information sources and the tools necessary to handle them.

4.6 Regulatory issues

The field of information technology is subject to rapid change. In the rush to exploit new tools and new ways of creating and accessing information, regulatory issues are often neglected or brushed aside. The great variety of coding systems devised by individual scholars for textual analysis of electronic texts, described in the previous section, is a case in point. Standardisation is always several steps behind innovation, but is nevertheless essential if information technology is to yield real benefits. Co-operation is hindered by a lack of common standards. Standards in the general context of computing and communications, such as the Open Systems Interconnection (OSI) model are, of course, relevant, but there are other areas which are more closely associated with humanities computing and where humanists can have a direct influence. An example is SGML, described above; its acceptance will transform electronic texts and electronic publishing generally. The fact that humanities information is in the course of great change is a good reason for developing standards, like SGML, which are extensible and have application across disciplines and across data types. Many other attempts are underway to develop functional and useful standards. The Museum Documentation Association (MDA) standards for object documentation, for instance, are fairly widely used although they are still in the process of evolution. An Information Standard relating to archaeological site-based information being produced by the Royal Commission on the Historical Monuments of England (RCHME) and the Association of County Archaeological Officers will be released in 1993.

A further issue in this context is that of intellectual property and copyright. The advent of electronic information systems has brought in its wake a host of problems which the 1988 Copyright Act has done little to address. These need urgent consideration if they are not to hinder the development of electronic publications and information resources.

4.7 Funding

Many of the observations made in this survey are inevitably concerned with funding. Much of what is recommended will require the Government, the funding and research councils, and the individual institutions of higher education to recognise that additional resources will be necessary if the humanities are to play their expanded role in higher education and to continue to produce scholarly research. At the same time there is much that scholars in the humanities can themselves achieve, both individually within their institutions and collectively by making their needs known to those responsible nationally for policy and funding.

That the existing arrangements for the public funding of humanities research are no longer satisfactory is confirmed by the conclusions of a working party established under the chairmanship of Sir Brian Follett by the ESRC and the

British Academy. After undertaking a review of the roles and relationships of these two bodies in the funding and promotion of research, this group recommended the establishment of a new granting agency, a Humanities Research Council, to bring humanities 'into a position comparable with that of the social and natural sciences', and also recommended 'that such an agency should offer the full range of functions appropriate to a research council. Its success, however, will depend upon extra resources being devoted to project-based research in the humanities' (Follett, 1992). The Humanities Information Review Panel welcomed the recommendations of the Follett report and took the view that an HRC could do much to improve the provision of information technology resources and services.

4.8 Conclusion

What this survey has demonstrated is that the use of information technology has made some inroads into the humanities in Britain. Where researchers have access to suitable equipment, software, support, and training they have done innovative and productive scholarship, whether this has involved the production of resources, the extracting of summary data, or the testing of hypotheses. This work has occurred at a time when advances in information technology have offered new opportunities for information collection, analysis, presentation, and dissemination. Some of these scholarly advances have come from the provision of bibliographies, library catalogues, museum registers, and citation indexes in electronic form; what is evident is that where these tools have been provided the benefits accruing from their use have justified their production. It would be difficult to dispute the claim that the humanities are underfunded and many scholars are underskilled to take advantage of the advances provided by technology. Unless greater efforts are taken to fund the development of new resources and the retrospective conversion of older ones, to equip scholars with hardware and software, to train them to use the equipment, and to provide them with technical support, humanities scholarship in Britain will suffer. The Panel thought that there were a number of opportunities open to improve information technology use and to support the future of humanities scholarship.

Section 5

Principal recommendations and follow-up activities

5.1 Principal recommendations

As the last section will have made clear, action will be needed on a large number of fronts if the potential advances in research revealed by this brief survey are to become the norm throughout the humanities. In part this will depend on action by scholars in the humanities, for surveys have revealed a culture of low expectations in terms of funding for equipment, maintenance, and support services, and a consequent underrepresentation on university computing and equipment committees. Although this situation is beginning to change, with a growing awareness of the potential benefits of information technology, humanities scholars must make their needs explicit and press for such representation. Unfortunately this change is occurring at a time when there is acute pressure generally on funding in higher education and hence shortages even among established users.

It is therefore essential that those responsible for the allocation of funds should ensure that support for information technology in the humanities (in terms of hardware, software, consumables, maintenance, and support staff) be at the levels expected in science and social science faculties, and that funding for research in the humanities recognises the true cost of using such technology. Similarly, there should be encouragement for the provision of a wide range of training opportunities for scholars in the humanities to develop skills in the application of information technology, especially among those with little experience in this field. The Information Systems Committee (ISC) has played an important role in this regard through its influence over the nature and funding of university information strategies. With the devolution of funding in 1993, it is highly desirable that its successor, the Joint Information Services Committee (JISC), continue to encourage the application of information technology in the humanities. The current free access to the Joint Academic Network (JANET) at point of use should be continued and extended to include its successor, SuperJANET. The sites linked to JANET should be extended from the current 200 sites to include museums, libraries, research institutes, and galleries. An expansion of this kind will greatly assist the development of an information-rich culture and in turn broaden and enliven scholarship.

Other necessary developments concern the supply of electronic information in the humanities. A national strategy is needed for the conversion of analogue material into digital form, and consideration should be given to the creation of a Humanities Data Archive, analogous to the ESRC Data Archive. A national

strategy should be devised for holding research material that will maintain comprehensive coverage, and provide user-friendly systems to ensure that access to such material, such as the National Register of Archives and the National Monuments Record (NMR), will be made available through JANET. Holding information in electronic form also requires attention to copyright implications and to the development and promotion of standards for the documentation and transfer of material in electronic form. It would be advantageous if the British Library and the British Academy were to create a database of computerbased projects in the humanities, in order to avoid duplication of effort. This should be accessible to all researchers.

5.2 Follow-up activities

The British Library has already made a start by providing support for a project to be undertaken by the Office for Humanities Communication (OHC) which will provide firm and up-to-date information on the use of information technology in the humanities in the United Kingdom, with reference also to developments in other European countries and in North America. This will build upon the work of the Review Panel. Anyone who would like to contribute to this new exercise should contact Dr Marilyn Deegan at OHC.

APPENDIX 1

BA and BLR&DD HIRP panel members

PROFESSOR J. T. COPPOCK (Chairman) Emeritus Professor of Geography, University of Edinburgh

E. S. AT WELL Division of Artificial Intelligence, School of Computer Studies, University of Leeds

R. P. CARR Librarian, University of Leeds

M. DEEGAN Director, CTI Centre for Textual Studies and Office for Humanities Communication, University of Oxford (from October 1991)

P. DENLEY Lecturer, Department of History, Queen Mary and Westfield College, University of London

N. GARDNER Director, Economic and Social Research Council Programme on Information and Communication Technologies

M. GRIEVES Assistant Director, The British Library Research and Development Department

S. M. HOCKEY Director, Center for Electronic Texts in the Humanities, Rutgers and Princeton Universities. Formerly Director, CTI Centre for Textual Studies and Office for Humanities Communication, University of Oxford (to October 1991)

PROFESSOR F. R. HODSON Professor of Prehistoric Archaeology, Institute of Archaeology, University College London

S. KENNA Project Manager, The British Library Research and Development Department

SIR ANTHONY KENNY President, The British Academy

M. A. PEGG formerly Director and University Librarian, the John Rylands Library, University of Manchester

A. ROSENHEIM Director of Electronic Publishing, Oxford University Press

S. ROSS Assistant Secretary (Systems), The British Academy

J. M. SMETHURST Director General - London, The British Library

B. S. SMITH Secretary, The Royal Commission on Historical Manuscripts

R. P. STURGES Senior Lecturer, Department of Information and Library Studies, University of Loughborough

PROFESSOR W. H. T. VAUGHAN Professor of History of Art, Birkbeck College, University of London

P. R. WILLIAMS Director, Division of Quality Audit, Higher Education Quality Council

PROFESSOR R. wiSBEY Professor of German, King's College London, University of London

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CHArt
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Computers and Philosophy Newsletter
Computersand Textsfrom CTI Centre for Textual Studies
Computers in Libraries
ED UCOM Review
History and Computing
Information Technoloy and Libraries
Library Hi Tech
Literary and Linguistic Computing
Musicus from the CTI Centre for Music
Online

APPENDIX 3

Bibliography of projects and services

The Panel wishes to thank these projects and many others not mentioned here for kindly providing information about their work.

AERIAL Photograph Rectification System,
Bradford University
John Haigh,
Department of Mathematics,
University of Bradford,
West Yorkshire BD7 1DP.
Tel: 021A 733466
Fax: 021'4 305340

ARCH-L,
Gesellschaft für Wissenschaftliche Datenverarbeitung mbH, Göttingen
E-Mail: ARCH-L@IBM.GWDG.DE

Beazley Archive,
Ashmolean Museum
Dr D. C. Kurtz, Archivist,
Ashmolean Museum,
University of Oxford,
Beaumont Street,
Oxford OX1 2PN.
Tel: 0865 278082
E-Mail: BOARDMAN@UK.AC.OX.VAX

BLAISE,
The British Library.
BLAISE-LINE,
Graphic Service,
Boston Spa,
Wetherby LS23 7BQ.
Tel: 0937 546600
Fax: 0937 546586
E-Mail: B. KEFFORD® UK. AC. RUTHERFORD. GEC-B

British National Corpus,
Oxford University Press, Longman Group UK Ltd,
W. and R. Chambers, Lancaster University Unit for Computer Research in the English Language, Oxford University Computing Services, and the British Library.
Ray Woodall,
Oxford University Press,
Walton Street,
Oxford OX2 6DP.
Tel: 0865 56767
Fax: 0865 56646
E-Mail: NATCORP@UK.AC.OX.VAX

BUBL,
Based at Glasgow University but run by Strathclyde University.
D. Nicholson, Co-ordinating Editor,
University of Strathclyde,
Curran Building,
101 St James' Road
Glasgow G4 ONS.
Tel: 041 552 3701
Fax: 041 552 3304
E-Mail: UK.AC.GLASGOW.BUBL

^Canterbury Tales« Project

Sheffield and Oxford Universities.
Dr Peter Robinson,
Oxford University Computing Services,
13 Banbury Road,
Oxford 0X2 6NN.
Tel: 0865 273221
E-Mail: PETERR@UK.AC.OX.VAX

Collate and Computers and Manuscripts Project,
Oxford University.
Dr Peter Robinson,
Oxford University Computing Service,
13 Banbury Road,
Oxford 0X2 6NN.
Tel: 0865 273221
E-Mail: PETERR@UK.AC.OX.VAX

Composer's Desktop Project,
York, Keele, Huddersfield Universities.
Dr Tom Endrich,
Composer's Desktop Project,
11 Kilburn Road,
York Y01 4DF.
Tel: 0904 613299
Fax: 0904 432450

Corpus of Contemporary Spanish,
King's College London.
Professor Barry Ife,
King's College London,
The Strand,
London WC2R 2LS.
Tel: 08 1 836 5454

Corpus of Romanesque Sculpture in Britain and Ireland,
British Academy,
Dr Seamus Ross,
The British Academy,
20-21 Cornwall Terrace,
London NW1 4QP.
Tel: 071 487 5966
Fax: 071 224 3807

CTI Centre of Music,
Lancaster University.
Lisa Whistlecroft,
Department of Music,
Lancaster University,
Lancaster LAI 4YW.
Tel: 0524 65201 ext 3445
E-mail: CTIMUSIC@UK.AC.LANCASTER

CURIA,
Royal Irish Academy, and University College Cork.
Dr Patricia Kelly,
Royal Irish Academy,
Dawson St,
Dublin, Eire.
Tel: 353 1 662 0363
E-Mail: CURIAPK@CCVAX.UCD.IE

DAEDALUS (A Video-Database of Images and Sources for Ancient Greek Sculptures and their Work),
King's College London.
Professor G. B. Waywell,
The Ashmole Archive,
Department of Classics,
King's College London,
The Strand,
London WC2R 2LS.
Tel: 071 873 2683
Fax: 071 836 1799
E-Mail: UDCL006@UK.AC.KCL.CC.OAK

Datasets Inter-Agency Group,
Professor John Slater, Chairman
c/o Higher Education Funding Council,

Northavon House,
Coldharbour Lane,
Bristol BS 16 1 QD .

»Dictionary of Old English,*
University of Toronto.
Nancy Speirs,
Room 14285, Robarts Research Library.
130 St. George Street,
University of Toronto,
Toronto, Ontario, M5S 1A1 Canada.
E-Mail: SPEIRS@DOE.UTORONTO.CA
The corpus is available on magnetic tape from the Oxford Text Archive (see below).

Eighteenth-Century Short Title Catalogue,
The British Library,
Editorial Office at the British Library,
Great Russell Street,
London WC1B 3DG.
Tel: 071 323 7607
Fax: 071 323 7782

Eleetra,
Manchester and Oxford Universities.
Dr Kathryn Sutherland,
Department **of** English,
Manchester University,
Manchester M13 9TL.
E-Mail: ELECTRA@UK.AC.OX.VAX

Electronic Text Library
Oxford University Press.
Janet Caldwell, Electronic Publishing,
Oxford University Press,
Walton Street,
Oxford 0X2 6DP.
Tel: 0865 56767

English Medieval Clergy Database,
Queen Mary and Westfleld College,
University of London.
Dr Virginia Davis, Project Director,
Queen Mary and Westfleld College,
Department of History,
Mile End Road,
London El 4NS.
Tel: 071 775 3191
Fax: 081 980 8400
E-Mail: V.G.DAVIS@UK.AC.QMW

English Poetry Full Test Database on CD-ROM,
Chadwyck-Healey Ltd.
Cambridge Place,
Cambridge CB2 INR.
Tel: 0223 311479

ESRC Data Arcjove,
Essex University.
ESRC Data Archive,
University of Essex,
Wivenhoe Park,
Colchester C04 3SQ.
Tel: 0206 872323
Fax: 0206 872003
E-Mail: ARCHTVE@UK.AC.ESSEX

European State Finance Database Project
Leicester University.
Professor R. J. Bonney, Director,
Department of History,
University of Leicester,
Leicester LEI 7RH.
Tel: 0533 522800
Fax: 0533 523986
E-Mail: HIS2@ UK. AC. LEICESTER

Hartlib Papers Project,
Sheffield University and Leverhulme Trust,
Dr Michael Leslie,

University of Sheffield,
Sheffields 10 2TN.
Tel: 01 Al 824807
Fax: 0742 478496
E-Mail: HARTLIB@ UK. AC. SHEFFIELD. PRIMEA

HEFCE/W Libraries Review,
Higher Education Funding Council England/Wales.
Lynne Brindley,
Librarian,
British Library of Political and Economic Science,
London School of Economics and Political Science,
Houghton Street,
London WC2A 2AE.
Tel: 071 405 7686
Fax: 071 242 0392

History Data Archive, feasibility study,
Cambridge Group for the History of Population and Social Structure.
Dr Kevin Schürer,
Cambridge Group for the History of Population and Social Structure,
27 Trumpington Street,
Cambridge CB2 1QA.
Tel: 0223 333194
E-Mail: SJA13@UK.AC.CAM.PHX

History News Bulletin,
CTI Centre for History with Archaeology and Art History.
Dr Donald Spaeth,
CTICH,
Glasgow University,
1 University Gardens,
Glasgow, G12 8QQ.
Tel: 041 339 8855, ext 6336
E-Mail: CTICH@UK.AC.GLASGOW

HUMBUL,
Oxford University.
Dr Stuart Lee, CTI Centre for Textual Studies,
Oxford University Computing Services,
13 Banbury Road,
Oxford OX2 6NN.
Tel: 0865 273221
E-Mail: STUART@IUK.AC.OX.VAX

Hypermedia in Laguage and Literature Subjects
Oxford University,
Dr Marilyn Deegan, Oxford University Computing Services,
13 Banbury Road,
Oxford 0X2 6NN.
Tel: 0865 273252
E-Mail: HILLS@UK.AC.OX.VAX

International Corpus of English Project
University College London.
Professor Sidney Greenbaum, Director,
Department of English,
University College London,
Gower Street,
London WC1E 6BT.
Tel: 071 387 7050 ext 3121
E-Mail: UCLESEU@UK.AC.UCL

Inventory of the Scottish Curch Heritage,
Council for Scottisch Archaeology, Churches Committee.
Miss Jill Harden,
Royal Museum of Scotland,
York Buildings,
Queen Street
Edinburgh EH2 1JD.
Tel: 031 225 7534

Kteio (KLEIO English Translation),
Southampton University, Queen Mary and Westfield College, Institute of Historical Research, The British Academy.
Dr Frank Colson, History Department, University of Southampton,
Highfield,
Southampton S09 5NH.
Tel: 0703 593079
E-Mail: Hn005@UK.AC.SOTON.IBM

LIVE videodisc,
Leicester University.
Clive Ruggles,
Department of Archaeology,
Leicester University,
Leicester LEI 7RH.

Machine-Readable Spoken English Corpus,
Lancaster University and University of Leeds.
Gerry Knowles,
Department of Linguistics and Modern English
Language,
Lancaster University,
Lancaster LAI 4YT.
Tel: 0524 65201 ext 3023
Fax: 0524 843085
E-Mail: EIA008@UK.AC.LANCASTER.CENTRAL

Mapping London in the 1690s,
Centre for Metropolitan History.
Craig Spence, Research Officer,
Institute of Historical Research,
34 Tavistock Square,
London, WC1 H9EZ.
Tel: 071 636 0272
Fax: 071 436 2183
E-Mail: METROLON@UK.AC.ULCC.CLUS1

Microcosm,
University of Southhampton.
Dr Wendy Hall, Director,
Department of Electronics and Computer Science,
University of Southampton,
Highfield,
Southampton S09 5NH.
Tel: 0703 592388
Fax: 0703 592865
E-Mail: WH@UK.AC.SOTON.ECS

Micro Gallery,
Ainsbury Wing, National Gallery, London.

MIT music project,
Massachusetts Institute of Technology.
Barry Vercoe,
Department of Music, MIT Media Lab,
Massachusetts Institute of Technology»

Cambridge, MA, USA.

Morelli Project,
Birkbeck College, University of London.
Professor W. Vaughan,
Department of History of Art,
Birkbeck College,
43 Gordon Square,
London WC11H OPD.
Tel: 071 631 6110
Fax: 071 631 6107
E-Mail: UBWC002@UK.AC.BBK.CU

Music and London Newspapers from 1660 to 1800,

Royal Holloway and Bedford New College, University of London.
Professor Rosamund McGuinness,
Music Studies,
Egham Hill,
Egham TW20 OEX.
Tel: 0784 443536
Fax: 0784 434455

NAR ONLINE
Royal Commission on the Historical Monuments of England.
Head of NAR Southampton,
NAR ONLINE,
RCHM(E),
Green Lane,
Maybush,
Southampton SOI 9FP.
Tel: 0703 780966
Fax: 0703 775970

National Museums of Scotland Databases and
Wealth of a Nation,
National Museums of Scotland.
John Burnett,
Head of Library and Documentation Services,
Royal Museum of Scotland,
Chambers Street,
Edinburgh EHI 1JF.
Tel: 031 225 7534
Fax: 031 220 4819

National Tithe Files Database (1836),
A Socio-Economic Survey of Land Use and the Agriculture Economy: the 1836 National Tithe Database. R. J. Kain, Compiler.
Adam Matthew Publications,
8 Oxford Street,
Marlborough, Wilts SN8 1AP.
Tel: 0672 511921.

NISS
Bath and Southampton Universities.
Bath University Computing Services,
University of Bath,
Claverton Down,
Bath BA2 7AY.
Tel: 0225 826036
Fax: 0225 826176
E-Mail: NISS@SWIRCC

Office for Humanities Communication
Dr Marilyn Deegan,
Director, CTI Centre for Textual Studies,
Oxford University Computing Services,
13 Banbury Road,
Oxford OX2 6NN.
Tel: 0865 56646
E-Mail: OUPJSC@OX.VAX

Oxford English Dictionary (Second Edition) on Compact Disc, Oxford University Press,1992.
Janet Caldwell, Electronic Publishing,
Oxford University Press,
Walton Street,
Oxford 0X2 6DP.
Tel: 0865 267979
Fax: 0865 56646
E-Mail: OUPJSC@OX.VAX

Oxford Text Archive
Oxford University.
Lou Burnard,
Oxford University Computing Services,
13 Banbury Road,
Oxford 0X2 6NN.
Tel: 0865 273238

Fax: 0865 273275
E-Mail: ARCHIVE®UK.AC.OX.VAX

Perseus,
Yale University Press.
Ms Heneritta Joy,
UK Sales Manager,
23 Pond Street,
London NW3 2PN.
Tel: 071 431 4422
Fax: 071 431 3755

PffILOS-L,
University of Liverpool.
E-Mail: PHILOS-L@UK.AC.LIVERPOOL

Port Books Programme,
Wolverhampton University.
Dr David Hussey, Director,
School of Humanities and Social Science,
Wolverhampton University,
Castle View,
Dudley DY1 3HR.
Tel: 0902 323499
Fax: 0902 323437

Potterne Midden Site,
Trust for Wessex Archaeology.
Dr Paul Reilly,
IBM UK Scientific Centre,
Hursley Park,
Winchester S021 2JN.
Tel: 0962 844191
Fax: 0962 840099
Internet: ReLLYP@wiNVMD.VNET. IBM.COM

Prosopography of the Byzantine Empire,
King's College London.
J. R. Martindale,
Department of Classics,
King's College London,
The Strand,
London WC2R 2LS.
Tel: 071 836 5454 ext 1018
E-Mail: UDLC052@UK.AC.KCL.CC.ELM

Prosopography of Italian Renaissance University Teachers and Students,
Queen Mary and Westfield College, University of London.
Peter Denley, Department of History,
Queen Mary and Westfield College,
Mile End Road,
London, El 4NS.
Tel: 071 775 3148
Fax: 081 980 8400
E-Mail: P.R.DENLEY@UK.AC.QMW

Renaissance Project,
Anglia University, Coventry Polytechnic,
King's College London, Cambridge University,
Keele University, Apple Computer.
Professor Stephen Heppell,
Learning Technology Research Centre,

Anglia University,
Department of Education,
Sawyers Hall Lane,
Brentwood CM 15 9BT.
Tel: 0277 264504
Fax: 0277 211363
E-Mail: HEPPELL@APPLELINK.APPLE.COM

Roman Bath,
University of Bath.
Dr A. Bowyer,
School of Mechanical Engineering,
University of Bath,

Bath BA2 7AY.
Tel: 0225 826115 x5453
Fax: 0225 826928
E-Mail: A.BOWYER@UK.AC.BATH

Shakespeare's Twelfth Night or What you Will
Anglia University, Coventry Polytechnic,
King's College London, Cambridge University,
Keele University, Apple Computer.
Professor Stephen Heppell,
Learning Technology Research Centre,
Anglia University,
Department of Education,
Sawyers Hall Lane,
Brentwood CM15 9BT.
Tel: 0277 264504
Fax: 0277 211363
E-Mail: HEPPELL@ APPLELINK. APPLE. COM

STELLA,
Glasgow University.
Jean Anderson,
STELLA Project,
University of Glasgow,
6 University Gardens,
Glasgow G12 8QQ.
E-Mail: STELLA@UK.AC.GLASGOW. VME

Study of the Cognitive Representation of Tonal Music,
Cambridge University, University of Liège.
Dr Ian Cross,
Faculty of Music,
Cambridge University,
West Road,
Cambridge CB3 9DP.
Tel: 0223 335185
Fax: 0223 335067

SuperJANET: potential for library and information services
Heriot-Watt University.
Michael Breaks, Heriot-Watt University Library.
E-Mail: LIBMLB@UK.AC.HW.CLUST

Teaching and Learning Technology Programme: Music Consortium
Lancaster University.
Anthony Pople,
Department of Music,
Lancaster University,
Lancaster LAI 4YW.
Tel: 0524 593776
E-Mail: CTIMUSIC® UK.AC.LANCASTER

Text Encoding Initiative,
Association for Computers and the Humanities, Association for Computational Linguistics, Association for Literary and Linguistic Computing.
Lou Burnard,
Oxford University Computing Services,
13 Banbury Road, Oxford OX2 6NN.
Tel: 0865 273238
E-Mail: LOU@UK.AC.OX.VAX

Thesaurus Linguae Graecae,
TLG Project,
Professor Theodore Brunner,
University of California at Irvine,
Irvine, CA 92717, USA.
Tel: 714 856 6404

VASARI project,
Birkbeck College, University of London.
Dr Kirk Martinez,

Department of History of Art,
Birkbeck College,
43 Gordon Square,
London WC 1 H OPD .
Tel: 071 631 6110

Wellington Papers Database,
Southampton University.
Dr C. M. Woolgar,
The Archivist,
The Library,
Southampton University,
Highfield,
Southampton S09 5NH.
Tel: 0703 593724
Fax: 0703 593939
E-Mail: C.M.WOOLGAR@UK.AC.SOTON

Winchester Graphics System and The 'WIMSOM'
Solid Modeller,
IBM UK Scientific Centre.
Dr Paul Reilly,
IBM UK Scientific Centre,
Hursley Park,
Winchester S021 2JN.
Tel: 0962 844191
Fax: 0962 840099
Internet: REILLYP@WINVMD.VNET.IBM.COM

Winchester History Project,
King Alfred's College.
Dr Martin W. Doughty, Director,
King Alfred's College,
Sparkford Road,
Winchester, S022 4NR.
Tel: 0962 841515
Fax: 0962 842280
E-Mail: MARTIND@UK.AC.WKAC

World of the Vikings,
York Archaeological Trust, National Museum of Denmark, and Past Forward Ltd.
Simon Hill, Director,
Past Forward Ltd,
1 Pavement,
YorkYOl 2NA.
Tel: 0904 670825
Fax: 0904 640029

APPENDIX 4

Abbreviations and acronyms

AI Artificial Intelligence
AIE Archaeological Information Exchange
BAB British Archaeological Bibliography
BLAISE British Library Automated Information Service
BLR&DD British Library Research and Development Department
BNC British National Corpus
BUBL Bulletin Board for Libraries
CBA Council for British Archaeology
CDP Composer's Desktop Project
CD-ROM Compact Disc-Read Only Memory
CHEST Combined Higher Education Software Team
CTI Computers in Teaching Initiative
DIAG Datasets Inter-Agency Group
DODO Daughter of DORA
DOE *Dictionary of Old English*
DORA Divided Object Ray-trace Algorithm
e-mail electronic mail
ESRC Economic and Social Research Council
FTP File Transfer Protocol
HEFC(E) Higher Education Funding Council for England
HEFC(S) Higher Education Funding Council for Scotland
HEFC(W) Higher Education Funding Council for Wales
HIRP Humanities Information Review Panel
HRC Humanities Research Council
HUMBUL Humanities Bulletin Board
GIS Geographical Information System
ICE International Corpus of English
ICECUP International Corpus of English Corpus Utility Program
ICPSR Inter-University Consortium for Political and Social Research
IP Internet Protocol
IRCAM Institut de Recherche et Coordination Acoustique/Musique
ISC Information Systems Committee
ISDN Integrated Services Digital Network
ISI Institute of Scientific Information
ISO International Standards Organization
IT Information Technology
ITTI Information Technology Training Initiative
JANET Joint Academic Network
JISC Joint Information Services Committee
MARSEC Machine-Readable Spoken

English Corpus

MDA Museum Documentation Association

MIDI Musical Instrument Digital Interface

MIT Massachusetts Institute of Technology

NAR National Archaeological Record

NISS National Information on Software and Services

NISSBB NISS Bulletin Board

NISSWAIS NISS Wide-Area Information Service

NMR National Monuments Record

OCP Oxford Concordance Program

OEDO xford English Dictionary

OHC Office for Humanities Communication

OPAC Online Public Access Catalogue

OSI Open Systems Interconnection

OUCS Oxford University Computing Services

OUP Oxford University Press

OWL Office Workstations Ltd

PC Personal Computer

RCHME Royal Commission on the Historical Monuments of England

RRD Research Resources Division

RSP Romanesque Sculpture Processor

SGML Standard Generalized Mark-up Language

SPSS Statistical Package for the Social Sciences

SQL Structured Query Language

STELLA Software for the Teaching of English Language and Literature and its Assessment

TEI Text Encoding Initiative

TLG Thesaurus Linguae Graecae

TLTP Teaching and Learning Technology Programme

VASARI Visual Arts System for Archiving and Retrieving of Images

WGS Winchester Graphics System

APPENDIX 5

Tradmarks

ARC/Info Doric Computer Systems, Doric House,23 Woodford Road, Watford, Herts WD1 1PR

BRS/Search BRS (Europe), 11 Weymouth Street, London WIN 3FG

dBase Ashton-Tate, Oaklands,l Bath Road, Maidenhead, Berks SL6 4UH.

DynaText Electronic Book Technologies Inc,l Richmond Square, Providence, RI 02906, USA

Guide Office Workstations Ltd, Rosebank House, 144 Broughton Road, Edinburgh EH3 4LE.

HyperCard Apple Computer UK Ltd,6 Roundwood Avenue, Stockley Park, Uxbridge, Middlesex UB11 1 BB

Idealist Blackwell Scientific Software, Blackwell Scientific Publications Ltd, Osney Mead, Oxford 0X2 OEL.

INGRES Relational Technologies Inc, 1080 Marina Village Parkway, Almeda, CA 94501, USA.

Micro-OCP *See* OCP.

OCP Oxford Electronic Publishing, Oxford University Press, Walton Street, Oxford 0X2 6DP.

ORACLE Oracle Corporation UK Ltd, The Oracle Centre, The Ring, Bracknell, Berks RG12 1BW.

SPSS SPSS UK Ltd,5 London Street, Chertsey, Surrey KT 16 8AP.

STATUS Harwell Computer Power Ltd, Curie Avenue, Harwell, Oxon, 0X11 OQW.

Toolbook Asymetrix Corporation, 110- 110th Avenue N.E. Suite 717, Bellevue, WA,98004, USA.

TRIP Paralog Systems International Ltd, Clerks Court, 18 Farringdon Lane, London EC1R 3AU.

APPENDIX 6

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