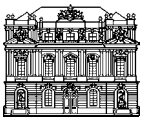
Michael Nentwich

cyberscience

Research in the Age of the Internet

Chapter 3

CYBER-SCIENCES – CYBER-HUMANITIES – CYBER-SOCIAL-SCIENCES



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"One of the notable features about the development of e-media in science is that they seem to vary in their structure, roles and uses from one field (or closely related set of fields) to another."
(Kling/McKim 1998, 178)

3 CYBER-SCIENCES – CYBER-HUMANITIES – CYBER-SOCIAL-SCIENCES

3.1 Introduction

Obviously, there are considerable differences among the various disciplines when it comes to the use of IC technologies. To name but a few examples: In physics, large central E-print archives have been established with thousands of uploaded research papers each year whereas in molecular biology no such archive exists. While papyrologists regularly use worldwide databases, no such thing exists yet in cardiology. Why is it that historians make widespread and innovative use of multimedia websites whereas anthropologists do not? How can we explain that scholars in Slavic studies do not attach much importance to E-mail discussion lists whereas tax lawyers use it frequently?

While such differences are occasionally addressed in all other chapters of this study, the comparison is at the centre of this part. In the following section (3.2) I highlight the status quo of what I call here "cyberness" (cf. 1.2.3) in a number of (sub-)disciplines in the form of case studies. This is followed by a direct comparison of the disciplines with a view to the spreading of certain cyberscience phenomena (e.g. E-mail, E-journals, online databases, virtual institutes etc.). This section maps the wide variation and offers a preliminary analysis of the differences (3.3). The concluding sub-section (3.3.11) is devoted to an overall synopsis.

Besides the comparative description of the status quo – it is done here for the first time in a systematic way, and is a worthwhile endeavour in its own right – my ultimate goal is to find the factors that account for these differences. As will be shown here, the common distinction between the sciences and the humanities turns out to have no great explanatory power – for instance, papyrologists and physicists are equally "cyber". Obviously, other factors play a more important role, such as the publishing traditions, the existence of successful E-activists, and economically exploitable applications (see 3.4).

This entire part is based on the combination of, for the most part, newly generated empirical and existing data (e.g. Rutenfranz 1997; Scholl et al. 1996; OECD 1998; Walsh/Roselle 1999). In particular, a series of structured expert interviews has been carried out in 13 disciplines (comprising 36 sub-disciplines). These were amended by an extensive Internet enquiry (see 0.3.2). The research fields have been carefully selected to cover the humanities (e.g. philosophy or literature studies), the cultural studies (e.g. anthropology), the social sciences (economics, political science and sociology), the formal sciences (mathematics and law) and the natural sciences (life sciences and physics). The sub-disciplinary sample includes both basic research (e.g. high-energy physics) and more applied areas (e.g. biotechnology) and both large fields (e.g. cardiology) and tiny specialities (e.g. papyrology). Table 3-1 lists all sub-disciplines included in this study. Note that the abbreviations in the second column (POL, SOC^{E}, PHY^{S} etc.) will be used in the figures and tables of the subsequent cross-disciplinary comparisons.

Table 3-1: Disciplines and sub-disciplines included in the comparative study

Discipline	Abbreviation	Sub-discipline/speciality
Political Science	POL	European studies
Sociology	SOC^{E}	Empirical social research
	SOC^{S}	Social policy research (and related fields)
	SOC^{T}	Social science studies of technology
Biology	BIO^{M}	Molecular micro biology
	BIO^{B}	Biotechnology
	BIO^{O}	Molecular oncology
	BIO^{E}	Evo-Devo (Evolution-Development)
History	HIST^{E}	Early modern history
	HIST^{A}	North-American history
	HIST^{P}	Pre-history
Economy	ECO^{P}	Political economy
	ECO^{E}	Economic European studies
	ECO^{M}	Macroeconomics
	ECO^{R}	Regional economics
Physics	PHY^{H}	High-energy physics
	PHY^{F}	Fluorescence analysis
	PHY^{S}	Theoretical surface physics
Mathematics	MATH^{C}	Constructivistic mathematics
	MATH^{K}	K-theory
	MATH^{N}	Number theory
Classical studies	PAP	Papyrology (non-Arabic)
Medicine	MED^{C}	Cardiology
	MED^{N}	Neurology (pain research)
	MED^{I}	Immunpathology
	MED^{T}	Thorax anaesthesia
Language Studies	LAN^{S}	Slavic studies
	LAN^{L}	Applied linguistics
	LAN^{C}	Transdisciplinary cultural studies
Philosophy	PHIL^{R}	Ethics in risk analysis
	PHIL^{A}	Analytical philosophy
Anthropology	ANTH^{L}	Latin-American studies
	ANTH^{P}	Pacific studies
Law	LAW^{I}	Information law
	LAW^{E}	European law
	LAW^{T}	Tax law

As will be shown in section 3.3, a comparison at the level of whole disciplines is hardly fertile. There are often considerable differences within single disciplines, and noteworthy similarities between a sub-discipline in one discipline and sub-disciplines in others. In some cases, even the sub-discipline or speciality might be too much an aggregated unit. There are signs, at least in the biomedical sector, that it might be necessary to differentiate further and to decline to the level of working group or research unit or at least to research community (Knorr Cetina 1999).[327] The latter may or may not coincide with sub-discipline, e.g. depending on the overall number of researchers belonging to it. For instance, the answers of those four researchers interviewed in the area of European studies (a sub-discipline of political science) were far from unanimous in all respects. However, I shall point at these special circumstances only if I have any evidence that they may play an important role. In general, I stay at the level of sub-disciplines for the purposes of this study since this is, in overall terms, the most fruitful level of aggregation.

3.2 (Sub-)disciplinary case studies

In this chapter, we will look closer at some selected (sub-)disciplines and their relationship to ICT. Here, the focus will, however, be on the description of the peculiarities and most striking cyber-applications to be found in each field.[328] Some of the information given here will later be repeated synoptically in the comparative chapter.

3.2.1 Humanities and cultural studies

A closer inspection of the state of affairs in the humanities and cultural studies reveals that it is a prejudice that ICT would not play a role there. To say the least, this study shows that a much more differentiated picture has to be drawn. As the American German studies scholar Mueller argues, "humanities computing is almost as old as computing, but in its narrow and early definition it was the business of a tiny group of enthusiasts (...). But for every scholar in the humanities, information technology has changed and is

[327] Note that this argument is about the appropriate level of aggregation and not the same as saying that there are always exceptions on the individual level. It seems likely that the "history" of a speciality plays an important role. For instance, the contingencies of transatlantic co-operations may lead to a greater incentive to use E-mail.

[328] The following *division into humanities and cultural studies, natural and applied/engineering sciences, formal sciences, and social sciences* is by no means intended to be authoritative. Some of the disciplines are divided internally in their assignment to one or the other category. For instance, anthropologists may think of themselves either as belonging to the humanities or the social sciences or the cultural sciences. Mathematicians are divided upon whether to attribute their field to the natural sciences or the humanities or to avoid the attribution altogether by labelling it "sui generis" or by "inventing" a new group, "formal sciences" – which I do here. It may seem odd to list legal studies together with mathematics, but the lack of a more convincing alternative, the *sui generis* character and the formal, deductive approach of legal studies suggest this choice as acceptable. While in general, I shall not use this attribution of disciplines to groups of disciplines for any theoretical purposes, I will make reference to it in 3.4.4.1 (when I refute the hypothesis that, in general, the natural sciences are more open to the use of ICT than the other groups of disciplines).

still changing the tools of the trade." (2000a, 1)[329] He tells us the story of the computer in the humanities as "a three-part story that began with the electronic library catalogue, went through the stage of the personal computer as word processor, and has recently entered its third stage of internet based resources." (ibid.) We are not witnessing the early beginnings of cyber-humanities, but according to Mueller, we are right in the middle of an all-encompassing development. For instance, in 1998, the future of computing in the humanities was the topic of a roundtable meeting with humanities scholars and computer and communication scientists held by the Computer Science and Telecommunications Board (CSTB 1998). The roundtable concluded that "[d]espite an initial lower penetration of information technology, funding constraints, and inherently conservative methods, the humanities, like other groups in society, are making greater use of computing and communications for efficiency, long-distance interaction, and new forms of activity made possible by technology." Hockey (1997a, 4) adds that hypertext has become popular in the humanities due to the potential for hyperlinking between multiple versions of the same text (e.g. in the project Model Editions Partnership[330] or in the Perseus project[331]). Also SGML and TEI are an important subject in the humanities (see Hockey 1997a; 1997b). Project Muse[332] gives access to over 100 E-journals in the humanities and social sciences (Neal 1997).

Not all observers welcome the increasing „cyberness". For instance, Mittelstraß argues that the traditional working methods of the humanities should not be given up. The humanities have what he calls a "healthy conservatism" in this respect because they "do not build a tower of positive knowledge" (1996, 27). And Hockey argues that some kinds of databases (the so-called relational databases) "work well for some kinds of information, for example address lists etc., but in reality not much data in the real world fits well into rectangular structures. This means that the information is distorted when it is entered into the computer, and processing and analyses are carried out on the distorted forms, whose distortion tends to be forgotten. Relational databases also force the allocation of information to fixed data categories, whereas, in the humanities at any rate, much of the information is subject to scholarly debate and dispute, requiring multiple views of the material to be represented." (Hockey 1997b, 4)

These issues can certainly not be resolved on a general level. Let me therefore look at the situation in the various disciplines.

3.2.1.1 Language studies

Under this heading I studied three rather diverse sub-disciplines: (1) literature studies, (2) applied linguistics and (3) transdisciplinary cultural studies.

(1) Literature studies

The study of literature, art and drama, i.e. the interpretation and analysis of texts, is the paradigmatic humanities discipline. Hence much of what has been said in the introduction to this sub-section (3.2.1) fully applies to literature studies. However, not all sub-disciplines are alike, and they seem to be regionally differentiated, too.

[329] Other authors reflecting on the relationship between the humanities and information technologies are, inter alia, Füssel (2001), Poser (2001), and the contributors to Gordesch/Raasch (1996).
[330] <Cyberlink=370>.
[331] <Cyberlink=373>.
[332] <Cyberlink=380>.

One expert interviewed in this study is a specialist in *Slavic studies*. The picture he draws is one of a rather traditional sub-discipline with only little technology involved in the daily work of the scholars, except for the PC as word-processor and some bilateral E-mailing. E-mail is not used by all, in particular not by those residing in the main countries of this literature, i.e. in Eastern Europe and Russia. There are no E-journals, no use of multimedia or hypertext, no E-conferencing, no E-pre-print servers, not even E-mail discussion lists are common, not to speak of the use of groupware or virtual institutes. There are only a few text databases. Since they are not online, but on CD-ROM, nothing exists yet which could be called a digital library of the field. However, there is a project to make all classical Russian texts available in full text. In sharp contrast to many other fields, there are only beginnings to digitise the bibliographies in literature studies, card catalogues still seem to be the rule. The Internet is used mainly as "yellow pages" of the field, which are not too comprehensive and rather unstructured. There are link collections that help to find other researchers or homepages of institutes. Compared to other fields, however, they are in most cases not yet comprehensive and sophisticated information tools (for one more advanced institutional homepage, see SlaWeb[333]).

German studies, at least in the American community, seems to be more technically advanced. Nathenson speaks of signals of a "level of technological maturity among humanists that for a long time was thought unobtainable". He reports that most of his colleagues use E-mail "as their primary means of communication among each other". Many of them have learned "to create and maintain web pages" (2001, 2; see also Mueller 2000a). Also there is a comparatively active E-mail discussion (GSLIST)[334]. Nathenson (2001) nevertheless deplores the state of academic publication in his field with the well-known claim that it is too slow and does not favour debate and co-operation. He propagates, without much success yet, new models of E-publication with ex-post quality control though (see 8.2.2.1). A number of universities offer electronic full text archives of classical texts (e.g. the "e-text center" of the University of Virginia[335]). An impressive example of a disciplinary database is "Projekt Historischer Roman", a comprehensive bibliographical database on historical fiction in the German language, with a clickable map as gateway to the database entries.[336]

When it comes to *English and American literature*, I found a number of highly interesting examples of state-of-the-art Internet applications. For instance, the "Blake Archive"[337] is a sophisticated archive of illuminated books with transcriptions. Java applets show details of each plate and scholarly annotations. The "Romantic Circles Web" site[338] is an interesting example of how collaborative literature studies could be organised in the Internet. This homepage is devoted to the study of literature and culture in the Romantic period. Romantic Circles is the collaborative product of an expanding community of editors, contributors, and users around the world. The contributors and editor use an interactive MOO[339] environment for the development of the site. A similar endeavour is the collaborative "Orlando" project[340], which intends to produce a chronology of women's

[333] <Cyberlink=584>.
[334] <Cyberlink=692>.
[335] <Cyberlink=585>.
[336] <Cyberlink=586>.
[337] <Cyberlink=395>.
[338] <Cyberlink=381>.
[339] See 2.4.7 on groupware.
[340] <Cyberlink=371>.

writing and related literary, social and historical events, an electronic text base and three E-volumes of the history of women's writing.

The "Project Gutenberg"[341], a genuine digital library initiative, also serves the research community of English and American literature. It includes full texts of many classical texts, which are no longer protected by copyright laws. They are available for free. As they are digitised, they can be searched for individual words or combinations of words. Brandtner (1998) describes manuscript and autograph archives in literature studies.

(2) Applied linguistics

In this field, almost everyone has an E-mail address and uses this medium frequently. E-journals do exist in moderate numbers. Although they are not often quoted, they have medium standing – depending on sub-fields. Linguists like to communicate via E-mail lists and, depending on the phase of one's career, you may lose out on important information if you have not subscribed. E-conferencing is rather exceptional, as is the use of groupware. There exist many disciplinary databases, in particular text corpora and terminology databases. For instance, the text corpora of the Institute for German Language in Mannheim[342] contain over 1700 million text words for linguistic purposes. Those offering language resources recently founded the Open Language Archives Community (OLAC)[343] which is an international partnership of institutions and individuals. They are creating a world-wide virtual library of language resources by both developing consensus on best current practice for the digital archiving of language resources and developing a network of inter-operating repositories and services for housing and accessing such resources.

E-pre-print servers do not play an important role, but exist in a few specific areas, e.g. in computer linguistics[344] and with regard to the language of New Labour in the Britain[345]. Linguists tend to explore the potentials of multimedia and hypertext structures. Hence, there are quite a few sophisticated websites available in the field, in particular, when it comes to applying linguistic knowledge in the sphere of museums. For instance, Ron Scollon's Quick links web page[346] gives access to a number of examples in kind.

Genuine virtual institutes are not known, but in some respect, virtual organisations are to be found. "For reasons of self-marketing", as one of the interviewees noted.

(3) Transdisciplinary cultural studies

While many representatives of various disciplines would use the label of "cultural studies" to denote their field (e.g. anthropology, literature studies, human ecology, cultural landscape research), there is also a not quite large, but widely spread and active research community describing itself as engaged in the interdisciplinary and/or transdisciplinary study of culture. In this field the proportion of those without E-mail access dropped to almost zero over the last few years. As the research community is reaching out to vari-

[341] <Cyberlink=26>; the texts are mainly in English; there is also a (much smaller) German branch of the project (Gutenberg-DE), recently in trouble as its sponsor (AOL) backed out.
[342] <Cyberlink=638>.
[343] <Cyberlink=631>.
[344] <Cyberlink=864>.
[345] <Cyberlink=710>.
[346] <Cyberlink=637>.

ous disciplines, many E-journals exist which are considered relevant. Some of them have high prestige (e.g. TRANS[347]), others are less quoted or quickly vanish again, for example Paideusis–JICS[348].

Hypertext or multimedia applications play a role as objects of research (e.g. in lyrics or fiction), but less so as a means of presenting research. One example is the E-book on CD-ROM "Hyperfiction"[349], a doctoral thesis.

While there are a few examples of E-conferencing, one cannot say it is widespread. Researchers in this community co-operate worldwide, mainly by using E-mail (not groupware). This is one of the sub-disciplines with a paradigmatic "digital institute", the INST[350]. It is not completely virtual as there is a small office with two people in Vienna who, among others, run the institute's web server, but even the co-ordination group is not based in Vienna. The INST homepage provides manifold tools for communication among the researchers involved in various projects. To name just one example, the "Encyclopaedia of Multilingual Cultural Studies"[351] is a transdisciplinary and trans-national co-operative project with a view to collect cultural experiences in their concrete linguistic forms and to develop new research terminologies. The virtual organisation lends continuity to this dispersed group of scholars for the time in-between the various conferences and workshops and allows them renewing social ties and communicating with each other face-to-face.

3.2.1.2 Philosophy

In general, philosophy is book-oriented and co-writing is rather seldom. Numeric data or pictures, which you could store in databases, do not play a role, and pre-publications have no tradition. Consequently, not too much technology is to be expected in the daily work of philosophers. However, this picture is true for only some areas, but not for all, as there are E-promoters among the philosophers. To begin with, E-mail has become a standard communication tool also in this community. There are some E-journals, and a growing proportion of the printed journals are also available online. The prestige of the E-only publications is rather low as they are still trying hard to get established. So far, they are only rarely quoted outside the E-journals themselves. Only one journal devoted to technology and philosophy (which seems to have stopped publishing in 2000) was highly esteemed as the editors and authors were renowned. E-conferencing is not practised, no virtual institute has been established, nor is groupware used for research (by contrast, one interviewee reported groupware use for teaching purposes). Given the rather low level of co-operation and co-authorship in philosophy, the attempt to do philosophy collaboratively and via Internet in the "Principia Cybernetica project"[352] seems rather exceptional.

The only attempt of an E-pre-print server (run by an Austrian philosopher) has not taken off. By contrast, digital and virtual libraries have started playing a more important role. There are increasingly full text collections, e.g. of French authors or in Latin, but also encyclopaedic or lexical projects. Furthermore there are special sites focusing

[347] <Cyberlink=694>; note that the journal TRANS is also published, in large intervals though, also in CD-ROM format.
[348] <Cyberlink=682>.
[349] <Cyberlink=644>.
[350] <Cyberlink=643>.
[351] <Cyberlink=642>.
[352] <Cyberlink=382>.

on particular topics, like ethics in risk assessment, as well as dedicated homepages for prominent philosophers and their oeuvre. Search-engines like PhilLex[353] make these resources searchable. There are many active discussion lists about various sub-fields of philosophy and about particular classic authors. One interviewee argued that, obviously, discussion lists suit well the needs of philosophers who love to discuss and argue. An able moderator is, however, needed to facilitate, structure and concentrate the written debate that easily gets lost in too many threads. Many of the lists are more of the question and answer type, but with active participation.

When it comes to philosophers' experiences with multimedia and hypertext, only isolated examples can be found. There are a few activists experimenting e.g. with the interactive MOO/MUD environment[354]. There are a few sites with video and audio files of speeches or radio programmes. But, at the end of the day, philosophy remains a very text-oriented endeavour with not much potential for graphics. Hypertext, by contrast, may have a future in philosophy, but there is only little yet. For instance, Becker (1995, 6) reports that organising into a hypertext web "seemed the only practical way to present someone's work, as in the case of the papers of Charles Sanders Pierce, the American philosopher who left thousands of scattered and unorganized pages, all having multiple connections and relevances within and across pages." Given the widespread use of discussion lists, archives of these discussions in hypertext format may have some potential.

3.2.1.3 History

ICT use in history has already a longer tradition (Thaller 1989; 1990). However, historians do quite diverse things, in particular if they look at different periods in time and different regions. Accordingly, it turned out that the state of ICT use varies. In my sample, I had specialists in the history of early modern Europe, in modern North-American history and in European pre-history (archaeology). While there seem to be no considerable differences with regard to spread of E-mail, discussion lists are not too important in archaeology while those studying more recent history, in particular American history and social, cultural and gender history, find it most valuable. In particular the list H-net with its subgroups plays a central role in the discipline as they help to stay up-to-date with what is going on in the speciality (e.g. jobs or conferences) and for getting information which is not available locally. Even the pre-historian (archaeologist) in the sample mentioned a recent interesting debate about a particular research issue. As a great British historian noted about his own field already in 1997:

> "Cheap international travel and transcontinental communication through e-mail have effectively abolished the boundaries between scholars of different nations; conferences and seminars on an international basis are held almost daily, increasingly by electronic means; the Internet is now enabling scholarly research and debate to be disseminated worldwide almost instantaneously." (Evans 1997, 177)

Hahn praises the potential for cultivating regional and international contacts via E-mail and the Internet, for participating in international co-operations etc. (1998, 33). Indeed, at least in the US community of American history scholars, E-conferencing was reported to even take place frequently. In other parts of the world and other sub-fields this is still exceptional, as is groupware for co-operation.

353 <Cyberlink=601>.
354 <Cyberlink=696>.

Among the humanities, history is at the forefront when it comes to electronic full text journals, based in particular in the US and the UK. In American history, there are quite many E-journals with a broad range of topics and lively debate sections. In particular, book reviews are published increasingly online.[355] However, not all fields have pure E-journals: in the field of early modern European history, for instance, none could be named. Their prestige is not to be compared with the print journals yet, but, at least in some specialities (like American history) higher than in many other disciplines.

History wins the prize for innovative multimedia and hypermedia websites. You can find 3D animations in VRML technology of archaeological sites, sophisticated databases of all kinds of primary sources like pictures, scans of hand-written documents, election speeches etc. Whole archives have been digitised not only to make them available for non-local historians, but also with a view to use the query software to solve innovative research questions. For sure, primary sources in some fields like archaeology cannot be digitised with the same accuracy in digital form and comparison may be more difficult than with the original (cf. also Leskien 1996, 115). But there are already examples of databases offering images of the artefacts with rich, searchable descriptive information in text (e.g. the one of the department for pre-history of the Viennese Museum for Natural History which is, however, not online yet[356]). The following quote underlines the perceived usefulness of the New Media for producing source editions:

> "In the case of history, a discipline where the crisis in scholarly publishing is particularly acute, the attraction of an e-book should be especially appealing. Any historian who has done long stints of research knows the frustration over his or her inability to communicate the fathomlessness of the archives and the bottomlessness of the past. If only my reader could have a look inside this box, you say to yourself, at all the letters in it, not just the lines from the letter I am quoting. If only I could follow that trail in my text just as I pursued it through the dossiers, when I felt free to take detours leading away from my main subject. If only I could show how themes crisscross outside my narrative and extend far beyond the boundaries of my book. Not that books should be exempt from the imperative of trimming a narrative down to a graceful shape. But instead of using an argument to close a case, they could open up new ways of making sense of the evidence, new possibilities of making available the raw material embedded in the story, a new consciousness of the complexities involved in construing the past." (Darnton 1999, 9)

Similarly, St. Laurent (1992) forcefully advocates hypertext in history writing (see also in chapter 4). He describes the historian's task as that of a "shaper of links between what are often widely disparate accounts", of an assembler of small parts to make a story about what might have happened and why. Because of hypertext's emphasis on the links between text rather than its content, it may be a good medium for history. St. Laurent imagines "an experimental history where the 'author' simply assembles primary sources and writes by placing links between them, allowing the reader to draw their own conclusions." (1992, 6) He acknowledges that this "might not be an ideal model for all history, but its successful implementation could raise some good questions about the type of project history wants to be." Furthermore, hypertext would offer the opening to multiple voices instead of bias. A further core advantage of hypertext is that it is particularly well suited to present strings of processes simultaneously instead of one after the other (linear–chronological).[357]

[355] For instance on HSozKult (<Cyberlink=691>).
[356] <Cyberlink=701>.
[357] An interesting example trying to implement simultaneity of aspects and events is "66 Jahre einer Zeitenwende" (<Cyberlink=896>).

And indeed, there are already a few examples that profit from the new possibilities. The project "Valley of Shadow" is a huge site comprising sources of all kinds on the American Civil War in a tiny region. The user (professional or hobby historian) is presented a graphical interface in the form a castle's floor-plan with rooms to enter specific sections of the material, like "letters" or "newspapers" etc. A further example is the "Endeavour Project"[358], a hypermedia site with Captain Cook's journals of his first Pacific voyage. It allows to jump directly to the journal entries of a particular day with images and maps aside. One can compare directly what other travellers have written the same day. Today, these sites are still perceived as add-ons to the rest. However, there is a sense in the discipline that the printed book and article will not vanish, but that online source editions may soon become an accepted (and rewarded) additional way of doing history. As Hockey puts it: "... the printed page is not [a] very good vehicle for conveying the information which documentary editors need to say. It forces one organizing principle on the material (the single linear sequence of the book), when the material could well be organized in several different ways (chronologically or by recipient of letters). Notes must appear at the end of an item to which they refer or at the end of the book. ..." (1997b, 10)

Given the in some respect quite advanced state of technology use, it is interesting to note that the historical sciences have not yet much advanced on the path towards digital libraries. There is "Project Gutenberg" (see above) with many important historical texts and there is the large history of private law archive[359] of the German Max Planck Institute for Legal History. But in most areas, including pre-history there is not even a good bibliographic database including more than book titles and authors from after 1985. See, however, the impressive HistoryEbook project[360] which aims at converting a backlist of some 500 titles, and a number of new books, into E-books.

3.2.1.4 Classical studies (papyrology)

Classical studies are a broad area, comprising many sub-disciplines, such as epigraphics, numismatics, Egyptology, classical philology etc. My case study focuses on papyrology. Given the great variety of approaches and subjects of the various fields grouped together under the label 'classical studies', this tiny field cannot be taken as representative for all classical studies.[361] In general, classical studies are not at the forefront of Internet use. There is, however, a growing number of websites also in this area (Alvoni 2000) as well as initiatives as regards teaching and multimedia, e.g. the project Telemachos[362] (Cristofori et al. 2000), and one Scandinavian E-journal[363].

Papyrology is a surprise case for the uninitiated. My experts reported that already at the beginning of the 20th century a group of papyrologist-entrepreneurs started a co-operative endeavour to work on (at that time low-tech) databases to help the community to fulfil their task. In the later decades of the last century, this culture of co-operation was backed by ever increasing capabilities of computing and the descendants of the early activists together with the tiny community produced ever more sophisticated tools – al-

[358] <Cyberlink=695>.
[359] <Cyberlink=568>.
[360] <Cyberlink=246>.
[361] To underline that papyrology is a special case, I decided to abbreviate this field with PAP and not CLA[P] (or similar).
[362] <Cyberlink=872>.
[363] <Cyberlink=876>.

ready in the 1960s, researchers from Liège made word lists with punch-card technology! Today, there are many online databases which have been previously on CD-ROM; full text archives of about 95 % of all edited papyri and perhaps 10 % of all photographs of papyri are also online. The Heidelberg/Duke database[364], for instance, has some 45,000 entries. In particular, David Packard jr. (son of the co-founder of the computer firm Hewlett-Packard) has invested enormous sums for 15 years to generate a comprehensive database of all papyri and inscriptions. All this can be searched with powerful tools to filter through all the decentral resources[365].

These new and powerful tools were supplemented with almost universal E-mail access and one active central E-list (plus a few specialised ones) for questions and answers and co-ordination. By contrast, neither groupware nor E-prints nor E-journals are known in the field. While there is no digital library comprising the research literature (online very, very few are online[366]), there are electronic full text editions of ancient classic texts, which are useful when it comes to comparing papyri with old texts.

Although physical access to an archive of papyri is important for any scholar in the field, it is not essential for research, as photographs of papyri can be sent back and forth and this is increasingly done via E-mail with attached scans. The papyrologist community is very small (a core of perhaps 50, and a wider group of no more than 300 researchers) and co-operative. In some sense it could be perceived as a large, worldwide virtual institute. Indeed, one interviewee reported of plans in 2001 to found a "virtual school" of the twenty or so papyrologists specialising in Arabic papyri.

3.2.1.5 Anthropology

Although E-mail is used widely or by nearly all, anthropology seems not too "cyber" as compared to other disciplines: there are only very few E-journals, no E-conferencing and no virtual institutes. There are very few discussion lists, in particular if we take the relative number, but my respondents perceive these lists as quite important. There seems to be considerable variation among the various sub-fields. Pacific studies, for instance, have more intense use of ICT. In the latter field, you find at least isolated examples of hypermedia applications (still mainly in CD-ROM format) and there is a well-known virtual library and resources site, the Coombsweb[367], which includes newsletters, discussion lists, link collections, E-journals and a structured E-print archive (based on FTP). In ethnography, a number of databases can be found which are called "atlases"[368]. Other online databases, e.g. by UNO and other international organisations, are frequently used by anthropologists. Also bibliographic databases are a standard tool in the field, too.

The potential of the new media seems large, though. Dicks/Mason (1998) investigate "the beginnings of a new attention to hypertext and hypermedia [which] are material-

[364] <Cyberlink=554>.

[365] E.g. through the Advanced Papyrological Information System (APIS) interface (<Cyberlink=634>).

[366] The only exception are older issues (so far up to 1998) of the Zeitschrift für Papyrologie und Epigraphik (<Cyberlink=825>); as regards bibliographies, there is at least the one on the excavations of Mons Claudianus available on the Web (<Cyberlink=826>) and the Bibliographie Papyrologique is available on CD-ROM only.

[367] <Cyberlink=683>.

[368] E.g. the Ethnographic Atlas Crosstabulations (<Cyberlink=697>) or the White-Veit EthnoAtlas (<Cyberlink=561>).

ising on the horizon of ethnographic innovation". Not unlike history, also here this new form of knowledge representation may solve some of the problems of modern ethnography.

> "(T)he presentation of interlinking avenues of enquiry and the facility for switching among them aims to encourage readers to approach the ethnographic environment as a shifting matrix of connections rather than a fixed grid of self-contained narratives. (...) What is innovative about ethnographic hypermedia environments (EHEs), however, is that the potential for cross-referencing and for multiple linkages is integral to the medium itself, and can inform all phases of the research process." (Dicks/Mason 1998, 3.5)

3.2.2 Social sciences

Internet access became standard in the social sciences, too. It will be shown below, however, that there are noteworthy differences among the various disciplines. Generally speaking, economics is more "cyber" than sociology or political science.

As there are some common interests, a few Internet activities are not only relevant for one of the disciplines, but for all. For instance, the Social Science Information Gateway (SOSIG)[369] aims at providing a trusted source of selected, high quality Internet information for students, academics, researchers and practitioners in the social sciences, business and law. It is part of the UK Resource Discovery Network. See also the activities of the German society GESIS which publishes inter alia, a comprehensive link collection for all social sciences, the SocioGuide[370] (cf. Hellweg 1999). Equally, the SSRN eLibrary[371] is devoted to various social science disciplines and law.

3.2.2.1 Political science

In general, political scientists profit a lot from the Internet. Indispensable resources are increasingly online. For example, legal and preparatory texts, documents by institutions and groups participating in political decision-making (such as parties, NGOs, administrative bodies), and statistical data. For sure, political scientists still carry out interviews in the field, filter through printed material and watch the media. But the fact that the majority of players in politics now have their own web site (offering much more than they would have given away in pre-Internet times) makes the work of a political scientist much easier. Together with the availability of bibliographic databases and, increasingly, electronic full text of scholarly articles, a considerable part of the work of a political scientist has moved to cyberspace.

In all sub-fields, you find link-collections and resource collections. While there is considerable variation, the homepages of the research institutes and of the scholarly associations in the field as well as of conferences have long reached a high standard of information depth. A number of projects were initiated to build up common resources in the field. For instance, an Italian group advocated Hyperpolitics (De Rosa 2000; Calise/Lowi 2000), a worldwide resource depository based on a common thesaurus (but it is still unrealised). Mainly designed for facilitating teaching is the German project PolitikOn[372],

[369] <Cyberlink=235>.
[370] <Cyberlink=266>.
[371] <Cyberlink=460>.
[372] <Cyberlink=552>.

but it has also some potential to develop into a co-operative research tool. Another German project is PIN ("Politik im Netz")[373] which provides various resources and an E-(maga)zine. A model portal for resources in the field of international affairs is CIAO[374] from Columbia University Press. It publishes a wide range of scholarship writing from 1991 onwards, including working papers from university research institutes, occasional paper series from NGOs, foundation-funded research projects, and conference proceedings.

Looking closer at the sub-field included in my interviews here, namely *European Integration research*, we find that there are many online working paper series, but only one E-journal (EIoP)[375]. It started in 1997 and is, according to my interviewees, increasingly acquiring prestige. The "European Research Papers Archive (ERPA)"[376] combines the efforts of around ten high quality online working paper series in this field, providing a common access and full text search engine (cf. Nentwich 1999b). There is, however, now one central and open pre-print archive for this research community (but none in political science as a whole).[377] Some, but not all of the commercial P-journals in the area provide online access to the full text of their articles.

The full text servers and databases of the EU, which are now largely for free and available via the WWW, have become a prime resource for Europeanists and are used frequently. Also the OECD and other international organisations provide databases useful for researchers in European studies. Besides these official databases, there are only very few provided by researchers themselves (e.g. related to the EUI in Florence). As other political scientists, Europeanists are users of news(paper) archives (e.g. Agence Europe) which are increasingly restricted to paying institutions. There are also many specialised link collections to guide researchers. A genuine digital library, however, does not exist yet, as only a minority of scholarly articles are already available online.

E-mail is the standard means of communication among Europeanists for most purposes (not only organisational, but also content-related issues). List servers are primarily used for the distribution of information in the form of E-mail newsletters sent out e.g. by the national associations and less as a forum for discussion. These information lists are considered important by most. As it is a mainly text-oriented field, multimedia and hypertext does not play a role, except in some special, mainly teaching-related circumstances. Neither does groupware – except for file sharing in larger institutes – or E-conferencing. As for the latter, however, the European Commission is an activist and organises E-events from time to time. There is something you may call a virtual research unit *in statu nascendi*, namely the European Parliament Research Group[378]. It brings together researchers based in the US and Europe who are interested in the European Parliament. The group's web site features data-sets, working papers, conference announcements etc., but is not technically advanced as it lacks a restricted group area with groupware or similar applications.

[373] <Cyberlink=645>.
[374] <Cyberlink=393>.
[375] <Cyberlink=699>.
[376] <Cyberlink=215>.
[377] The Archive of European Integration (AEI; <Cyberlink=918>).
[378] <Cyberlink=700>.

3.2.2.2 Sociology

On a general level, the situation in sociology is quite similar to political science. The Internet is used frequently as it provides increasingly essential information for research. There are even fewer pure E-journals (with only limited prestige) and fewer, but equally important, E-lists. In general, the lists are perceived as an important tool for being well informed about what is going on in the field. In technology studies, E-conferencing seems to be taking place more often than average, which is at least from time to time. More widespread than genuine E-conferences are speeches transmitted via the Internet with a dedicated E-mail or web forum for discussion. There are only few E-print series and no sociology-only pre-print archive. However, sociologists participate in a multidisciplinary archive, the SSRN eLibrary[379]. SSRN seems however to be known and used mainly in the US, so far. Furthermore, I found only isolated examples of hypertext or multimedia in sociology.

Groupware is not yet known to any considerable degree. By contrast, in the field of technology studies, there is something we might again call beginning virtualisation of research units. The European Science and Technology Observatory (ESTO)[380] network is a dense network of members, spread over Europe, who carry out research upon request from a central EU research institute (IPTS). Communication is entirely carried out by E-mail, but while there once was a dedicated group web-space, it has been removed and it seems that at present, no more sophisticated tool is being applied. When it comes to organising collaboration over the Internet, the Forum Qualitative Social Research (FQS)[381] is a very interesting example. It is more than a multilingual online journal for qualitative research. Its description states that the "unique attributes of the internet – speed, flexibility, interactivity – are employed to develop, in comparison to traditional print media, new discourse forms and standards for quality". FQS is an experimental project that is organised in a participatory mode.

When it comes to disciplinary databases, the situation is again similar to the one in political science. Sociologists also rely on documents and data, such as statistics, which are increasingly made available by official institutions. Unlike political science, there are a number of organisations engaged in collecting and distributing empirical data stemming from individual research projects, e.g. the Zentralarchiv für Empirische Sozialforschung[382] in Cologne or CESSDA[383] in Norway. As in political science, all encompassing digital libraries do not exist in sociology, but services like SOSIG-Sociology[384] or SSRN eLibrary (see above) provide structured access to full texts.

3.2.2.3 Economics

In quite a number of respects, economics differs from the other social sciences included in this study. To begin with, working papers play a very important role in academic communication of economists. Most working paper series are online and there are huge archives collecting the meta-information of these papers to allow structured keyword, author and title search. For example, SSRN (see above) collects the electronic full text of papers

[379] <Cyberlink=460>.
[380] <Cyberlink=684>.
[381] <Cyberlink=496>.
[382] <Cyberlink=606>.
[383] <Cyberlink=605>.
[384] <Cyberlink=612>.

centrally and RePEc[385] collects only the meta-data, based on a special standard. RePEc also includes the meta-data of journal articles, plus software components. In some respects, this amounts to a genuine digital library, as almost all working papers and quite a few of the journal articles are even downloadable directly through this database. When it comes to electronically available journals, economics comes right behind the sciences, but there are relatively few pure E-journals. It comes as no surprise that their prestige was rated low with no considerable tendency to rise, yet.

Economics is also special in that there are at least two economics institutes that fulfil most criteria for true virtuality. Both the Centre for Economic Policy Research (CEPR)[386], whose non-virtual core is based in London, and the National Bureau of Economic Research (NBER)[387] based in Cambridge/MA rely on a large number of researchers based around the world. These researchers participate in the research projects of the two institutes without being present at the headquarters. To be sure, one of the tasks of the central offices is to organise face-to-face workshops and conferences, but distributed and cooperative research is at the heart of their mission.

As numeric data (e.g. time series) play an important role in economics research, online databases are frequently used and, in most fields, quite a few of them already exist. Often, they are not maintained by the research community itself, but by dedicated official institutions such as international organisations and national statistical offices. But there are also disciplinary databases from within the community to be downloaded through the homepages of individual researchers or their institutes (e.g. from NBER, see above).

Notwithstanding, economics is far from being "cyber" in each and every respect. For instance, E-conferencing is non-existent in economics research, groupware either not known or not used (not even by the two top (virtual) research institutes just mentioned), and there are relatively few E-mail lists which were rated as not (too) important by those experts included in my empirical study. Once again, distribution of information (e.g. conference announcements) rather than discussion is the main purpose of these lists.

When it comes to going beyond traditional publishing by including multimedia or hypertext structures, economics research seems to have an important potential as the following quote shows:

> "In economics, the web gives the possibility of mounting data sets and algorithmic information and so allows scholars to interact with the work of others at a deeper level than is possible in print. For example, Ray Fair maintains his 130 equation model of the US economy on the web with data sets and a solution method. Any scholar who wants to experiment with alternative estimations and forecasting assumptions in a fully developed simulation model may do so with modest effort." (Getz 1997, 3)

This potential, however, is not used much yet and there are considerable differences among the various sub-fields. There are at least isolated examples in regional economics and some more in macroeconomics. In the latter field, it is mainly data sets plus related analytical software that is made available through individual homepages. In regional economics, I found one genuine E-book using hypertext technology with a search function etc., the Web Book of Regional Science[388].

[385] <Cyberlink=214>; at the time of writing the amount of working papers accessible via RePEc surpassed 101.000; in addition, over 55.000 journal articles and a few hundred software components were listed.
[386] <Cyberlink=589>.
[387] <Cyberlink=615>.
[388] <Cyberlink=678>.

3.2.3 Natural sciences and applied/engineering sciences

There is a common presumption already referred to in the short introduction to the humanities section that, in general, the (natural) sciences are much more open for the application of technologies. This section will nevertheless demonstrate that a much more differentiated picture has to be drawn. In particular, it will become obvious that we have to climb down to the level of sub-disciplines to find that some of the specialities in the sciences are much less based on ICT than some of the fields mentioned in the previous sections (see also 3.4.4.1). In this study, I included physics and the biomedical sector (biology and medicine).

3.2.3.1 Physics

In some respects, physics is a model discipline when it comes to innovative ICT use for scholarly communication. Most prominently, physicists were involved in the early days of the ARPANet and the physicists at the CERN laboratories invented the WWW because they needed a common platform for data exchange within their extended research groups. The high-energy physicists also started with Ginsparg's first E-print server in Los Alamos, now called arXiv[389]. Meanwhile, the archive is extended to many (not all!) sub-disciplines in physics and to mathematics. The idea spread to other fields, too. Odlyzko (1994, 25) remarks that the transition from the old system to the automated E-print system was sudden (less than a year). He writes that today, physics almost exclusively relies on the E-pre-print system. Journals play a minor role in the communication of the latest research news as they come only much later in the information chain (but they certainly still play a role in terms of reputation). While there are E-print servers in other disciplines, too, the centralised system in some parts of physics together with individual uploading of papers seems to be most successful in terms of universality.

There are relatively few pure E-journals in physics, in particular if compared with the other two fields from the natural sciences. By contrast, many of the P-journals went online and are now available in both formats (e.g. the core "family" of journals, Physical Reviews, with its online access PROLA[390]). The prestige of pure E-journals varies among the sub-disciplines: while high-energy physicists rate their E-journals "medium" (which is quite high when compared to the assessment of other fields), their colleagues from theoretical and applied physics consider them to be of rather low esteem. The Living Reviews of Relativity[391] is a remarkably innovative E-journal which publishes continuously amended or updated review articles together with a state-of-the-art bibliographic hyperdatabase (see also sections 6.3 and 7.3.1.4).

At least for those physics fields which use arXiv or a similar system, we can speak of a universal digital library as nearly all written publications, and both pre- and post-publications are available online.[392] An early attempt of a digital library in another sub-field was the X-Ray WWW Server[393], which had, however, already been discontinued in 1995.

[389] <Cyberlink=216>.
[390] <Cyberlink=300>.
[391] <Cyberlink=237>.
[392] A detailed account of communication and collaboration in high-energy physics at CERN is given by Merz (1997). She describes the remarkable interconnectedness of this field, their communicative needs and collaborative practices and how electronic means have been incorporated, in particular the use of E-mail and E-pre-print archives.
[393] <Cyberlink=583>.

While you will find no innovative multimedia publication in the more applied fields of physics, there are at least some in basic research. The Astrophysical Journal (ApJ)[394], for instance, publishes lots of pictures and has a sophisticated web peer review system. My experts, however, considered most of these 3D animations less important for research and more apt for marketing and teaching purposes. One of the most remarkable examples of the use of hypertext that I came across in any discipline across the board, is to be found in experimental physics, namely the proposal for a modular publication system developed at the Van der Waals-Zeeman Laboratorium in Amsterdam (see e.g. Kircz 1998b; Harmsze 2000). It is discussed in-depth in 6.2.3.1.

Interestingly, there are only very few general or open E-lists in physics, but instead a lot of closed ones serving the smaller work groups. Only the expert interviewee in theoretical physics considered these lists "not too important". His colleagues from the other fields were convinced that they play an important or even very important role. It is interesting to note that most physicists interviewed reported that they still phone frequently. High-energy physics is one of the two fields where I have been informed of regular use of video-conferencing. By contrast, similar to other disciplines, groupware seems not to play any significant role. Nor did I hear of any genuine virtual institutes. I only found stable project groups, in particular in high-energy physics where international projects often last ten or more years. Physicists are, however, at the forefront when it comes to organising wide-area distributed computing, e.g. in the project DataGrid[395].

Disciplinary databases are an important tool for physicists, but there is variation among the sub-disciplines. While access to online databases is a daily routine for high-energy researchers, they are less important in theoretical physics. In applied branches, the important databases are often not available publicly or online, and sometimes not even in electronic format, as one expert reported. Particularly important are databases to access software components, see e.g. the computer program library for physics and physical chemistry (CPC)[396].

3.2.3.2 Life sciences I: biology

The life sciences are the leaders with respect to pure E-journals as well as parallel publications (P- and E-). In my ranking, biology is second place behind medicine. There is, however, again considerable variation among the sub-disciplines included. In the field "evolution-development" (Evo-Devo), there are only a few, while in microbiology there are hundreds. The expert in biotechnology counted none, but recently, in the framework of BioMedCentral[397], a new E-Journal was launched (BMC Biotechnology) and there seem to be a few others. This can be interpreted as an indication of the rather low prestige of E-only journals in the field. The reason given is that they are mostly not (yet) included in the rating systems. As this system is rigorously applied, publishing in those journals does not count in favour of one's career and is hence less attractive. But given the growing importance of BMC, things may change soon. Given the extremely low importance of pre-prints, it comes as no surprise that E-pre-print systems have not been established in

[394] <Cyberlink=410>.
[395] <Cyberlink=248>.
[396] <Cyberlink=679>.
[397] <Cyberlink=226>; see also in 9.1.3.

biology.[398] When it comes to innovative E-publishing, hypertext does not play a role – except for cross-linking between articles – but multimedia, in particular the extensive use of digital images, is well established in the field. Except for the field Evo-Devo, you will find many sophisticated digital enhancements in biology (accessible from the journals' web sites).

Another area of considerable "cyberness" in biology are online databases which are now among biologists' main resources: "Whether in centralised archives or decentralised databases, these resources play a catalytic role in advancing research." (OECD 1998, 199f., quoting Waldrop 1995) In particular, those biologists involved in micro or molecular biology depend on these world-wide online accessible databases, e.g. for gene sequences, enzymes and other "omes" (besides the genome, also the proteome, RNA etc.). Among the best known examples here are the one generated by the Human Genome (HUGO)[399] project, the overall GenBank[400], or the Online Mendelian Inheritance in Man (OMIM)[401] knowledge-base of human genes and genetic disorders.[402] Unlike other research communities (e.g. in the social sciences), all molecular biologists are, in some sense, working together. They store the research results of the whole field in these databases. In addition, there is closer co-operation. For instance the Worm Community System (WCS) in the early nineties was one of the first collaboratories and served the biologists studying *c. elegans*, a tiny worm (Finholt 2001, 12). Apart from this, I could not find virtual institutes or collaboratories as the work in the laboratory on the spot or in the field is too vital for this kind of research and cannot be done at distance (see, however, Finholt/Olson 1997 who reports further collaboratory attempts).

All biology experts considered what they have at hand amounts to a genuine virtual library – in particular, access to the whole journal literature via the PubMed[403] bibliographic database with links to full texts on the publishers' homepages and the BioMedCentral[404] full text journals, plus the virtual libraries VL biotechnology[405] and BioSciences[406] together with one-stop information sites like BioMedNet[407]. Already today, a high proportion of all recent publications is available online. The particularly short half-life periods for scientific literature in biochemical research may lead to a digitised publishing world very soon, if compared to other fields where there is a need to retro-digitise (cf. Mittler 1996, 77). A (so far) unique collaborative cyber-activity to facilitate and improve access to the immense wealth of scientific literature in the field is the project "Faculty of 1000"[408] which is an online research tool that highlights the most interesting papers in biology, based on the recommendations of over 1000 leading scientists.

[398] When Kling/Covi (1995) were "specially impressed by the way that molecular biologists who routinely share DNA sequences via genbank circulate paper pre-prints rather than electronic pre-prints", they were probably writing about internal circulation of draft papers rather than genuine pre-prints.

[399] <Cyberlink=408>.

[400] <Cyberlink=707>.

[401] <Cyberlink=218>.

[402] For an informing set of articles about various databases in biology, see the special issue (available for free) of Nucleic Acid Research (an E-journal by OUP) Vol. 30 No. 1 (2002) <Cyberlink= 706>.

[403] <Cyberlink=625>.

[404] <Cyberlink=226>.

[405] <Cyberlink=687>.

[406] <Cyberlink=545>.

[407] <Cyberlink=417>.

[408] <Cyberlink=649>.

While E-mail is used widely though not by all researchers in biology today, there are only few examples of E-conferencing. When it comes to E-lists, biology ranges in the middle field with different assessments of the importance of these lists: while biotech and "Evo-Devo" researchers think they are not too crucial, their colleagues from the other fields attach more importance to them. Note that there is only restricted use of ICT in other sub-fields of biology, like ornithology (Hailman 1996, summarised by Walsh/Roselle 1999, 68; cf. also OECD 1998, 199).

3.2.3.3 Life sciences II: medicine

When we look at the situation in medicine, the other branch of life sciences, it is comparable to biology but there are also noteworthy differences. As regards E-publications, medicine takes the lead: no other field has as many pure and parallel E-journals. Due to the lacking acknowledgement in the rankings, the prestige of the E-only journals is, however, similarly low as in other science fields. Only my expert in neurology thought that the esteem was growing. There are some examples of multimedia publishing and extensive linking in medicine, e.g. in the British Medical Journal (BMJ)[409]. There is also one interesting example of an E-book (both printed and on CD-ROM): an Encyclopaedic Reference of Cancer[410].

Some activists in the life sciences wanted to copy and extend the Los Alamos E-preprint idea with the "E-BIOMED" proposal (Varmus/et al. 1999) which eventually became in February 2000 "PubMed Central" (PMC)[411]. In contrast to the physics E-print archive, the original proposal aimed to introduce quality checks for its content without success: papers would be submitted either through (independent) editorial boards (of print journals) or directly after a simple screening for appropriateness. Today, PMC is a growing archive of electronic full-text journals (pure and parallel) whose publishers agreed to make the full-text available for free. A genuine E-pre-print archive, however, does not exist in this discipline, as there is no pre-print culture.

Reviews, i.e. articles about others' research and the state-of-the-art in a sub-field, play an important role in medicine. The medical community has seized the web opportunities. On a discipline-wide level, there is the so-called Cochrane[412] library, which publishes, in an online database, reviews written collaboratively by at least two parallel-working groups of reviewers. Another example is to be found in a speciality, thoracic anesthesia, with a "living library" as it is called which contains both reviews and further dynamically updated resources. As regards disciplinary databases, the answers of my experts were split: apart from the review and bibliographic databases, there are only few specialised databases. One example is PROTALL[413] provided by a network of medical scientists interested in food allergies.

In the US, medical collaboratories funded by the NIH (National Institute of Health), such as the Great Lakes CFAR (a collaboratory for AIDS Research[414]), provide for real-time audio-visual communication with document sharing, remote control of experimen-

409 <Cyberlink=309>.
410 <Cyberlink=628>.
411 <Cyberlink=258>; for an account of the transformation of the original E-Biomed proposal into PMC, see Kling/Fortuna/King (2001).
412 <Cyberlink=624>.
413 <Cyberlink=632>.
414 <Cyberlink=705>.

tal equipment, information search and retrieval, and transfer and storage of images and large data sets (for an overview see Teasley/Wolinksy 2001). Apart from experiments with video-conferencing in the collaboratories, there are also some examples of E-conferences in the form of life-video-streaming of keynote and other selected speeches at large conferences. But there is, so far, no interactivity. E-lists, however, are very widespread in medicine: indeed, there is no other discipline with as many lists. The assessment of their importance ranges from not important to important. It seems that the more specialised a list, the more interesting it is for the researchers.

3.2.4 "Formal" sciences

Under this heading, I list the two remaining, but almost incomparable disciplinary cases, namely mathematics and law.[415]

3.2.4.1 Mathematics

Mathematics has already had a long history of ICT use. For instance, Grötschel/Lügger (1996) describe the transformation of the communicative behaviour in mathematical science with a long list of E-journals, databases, and the like. In his seminal paper on the future of traditional scholarly journals, Odlyzko (1994) mainly drew on mathematics wherever he needed examples. And Bourguignon (1999, 109) wrote with respect to mathematics: "One can legitimately question whether in the not-too-distant future the production of a printed paper copy of a journal will become the exception rather than the rule". As of 1995, "(m)athematics has generated the largest number of online journals of any field. The first maths journals appeared online in 1993, and the majority are electronic-only." (Hitchcock et al. 1996, 7) Today, mathematics is – with respect to E-only journals – in third place behind the biomedical sector. With respect to the overall number of electronically available journals, it is in fourth place, the third being physics. There is, however, an important difference between mathematics and those disciplines with more electronic journals: the prestige of E-journals in mathematics, at least in some sub-disciplines, is much higher.

In many sub-fields, there are decentral E-pre-print servers (e.g. in number theory) or even central archives (e.g. in K-theory). In others, the working papers can only be retrieved through direct visits of the institutional homepages. Math-Net[416] (based in Germany, but intended to serve the worldwide community) and similar networks based in other countries[417], provide a one-stop-shop for mathematical resources, in particular working papers and software. Furthermore, mathematicians in some fields are engaged in innovative ways of making decentral resources searchable, e.g. in the project CARMEN[418] or OpenMath[419]. The former deals with meta-data and the treatment of (remaining) heterogeneity, as well as the retrieval of structured documents and heterogeneous data types. The latter is an emerging standard for representing mathematical objects with

[415] See already fn. 328.
[416] <Cyberlink=303>.
[417] E.g. Netlib (<Cyberlink=379>) and MathSciNet (<Cyberlink=822>), both US-based, but known worldwide.
[418] <Cyberlink=51>.
[419] <Cyberlink=578>.

their semantics, allowing them to be exchanged between computer programs, stored in databases, or published on the world-wide web. All this amounts to the perception of a genuine digital library, or electronic library (as is the term used in Math-Net).

While the empirical world does not play an important role in most mathematical sub-fields, mathematical databases are a basic working tool in some sub-fields. Hence, apart from the bibliographic or review databases like ZMATH[420], as well as E-print and software databases, there are a few other online databases, e.g. on prime numbers[421] which play a role in more applied mathematical research, e.g. in cryptography.

By contrast, there are only slight beginnings of virtualisation of institutions in mathematics. The virtual Institut für Wissenschaftliche Information (IWI)[422] in Germany is a math-related institute, but it is not genuinely doing mathematics, rather it is in the business of providing information. Other virtual entities in the US are teaching-related. Perhaps there is not much need for virtual institutionalisation as mathematicians mainly work alone or in stable bilateral co-operation. This might also be the reason for the remarkably low number of lively and active E-lists in mathematics. They are rated to be important only by one of my experts. E-conferencing is not widespread, either. Co-operation takes place nevertheless: there are a number of distributed computing projects in highly specialised mathematical fields, e.g. in prime number research.[423]

Hypertext or multimedia does not yet play a role in mathematics. As long as the issue of rendering, i.e. representing mathematical formulas in HTML is not solved, mathematical E-papers are almost always in Postscript format and, consequently, not apt for internal hyperlinking.[424] Multimedia will probably have no place in mathematics, as it is very text or rather formula oriented. The only examples of interactive web sites are to be found in relation to teaching (e.g. with a view to let students interactively "play" with different numbers and immediately see the results in changed graphs), but not with research. However, the web site of the Mathematical Sciences Research Institute[425] in Berkeley includes both videos of mathematical lectures and scans of hand-written (!) lecture notes.

3.2.4.2 Law

So far, legal scholars have been very selective in using the new media for research.

On the one hand, they adopted E-mail and also E-lists as standard communication tools, there are at least beginnings of virtualisation of institutes in specialised (mainly Internet-law-related) areas[426] and, above all, they use online databases a lot.[427] Legal scholars need fast access to up-to-date, as well as historical legal texts, judgements, opinions, commentaries and the like. The advent of online databases – in the beginning via specialised telecom networks, now much more convenient via the WWW – changed the cumbersome way of accessing this material. Today, almost everything needed in the dis-

[420] Zentralblatt (<Cyberlink=749>) and Mathematical Reviews (<Cyberlink=823>).
[421] Cf. "pLab" (<Cyberlink=639>).
[422] <Cyberlink=685>.
[423] See e.g. the Great Internet Mersenne Prime Search (GIMPS) project (<Cyberlink=575>).
[424] This may, however, have an interim solution as many mathematical papers are now also converted to PDF which allows internal and external linking.
[425] <Cyberlink=577>.
[426] Cf. Cyberspace Law Institute, a virtual institute under construction (<Cyberlink=619>).
[427] There is even a sub-discipline called "legal informatics" dealing with ICT use in legal scholarship (see e.g. Schweighofer 1999).

cipline is included in one of the many databases around the world. Some of these databases also collect scholarly articles and commentaries so that a genuine digital library is available on all lawyers' desktops. These databases are often provided for by commercial publishers[428] or by national governments and parliaments, as well as international organisations, such as the EU. Probably for the majority of legal scholars, access to the comprehensive legal database of the speciality means that access to a real library is restricted to a minimum. In addition to these online databases, there are extensive link collections that provide further structured access to resources relevant for legal research, such as the NetLaw Library [429], a complete directory of Internet-related law sources and the web portal of the Juristisches Projekt Saarbrücken[430]. Similar to the Faculty of 1000 project (in biology, see 3.2.3.2), but only *in statu nascendi*, is the Juristische Bibliographie[431], an interactive site with reviews of IT law-related articles.

On the other hand, there are only few electronic journals[432] in law and the prestige of E-journals is low – at least outside those legal specialities which are close to IT studies. Activists, like the US legal scholar Hibbitts, were not yet successful in convincing their community despite Hibbitt's (1996b; 1996a) extensive description of how legal scholarship's relationship with the new media evolved over the last years and his conclusion that a radical shift to online self-publishing with post-hoc peer review would serve the community most with a view to solving many of the problems of the traditional law journal system. Furthermore, there are no E-prints – perhaps with the exception of Internet law – and almost no hypertext[433] or multimedia publications. At least, some legal scholars use Internet publishing for teaching purposes.[434] When it comes to E-conferencing, only isolated examples can be reported.

[428] As a rule, these are not available for free, as the legal profession is prepared to pay for these invaluable services, but universities often have special arrangements. Good examples are, in Austria, the Rechtsdatenbank (RDB, <Cyberlink=676>) or, mainly in the US, but with world-wide branches, Lexis-Nexis (<Cyberlink=442>).

[429] <Cyberlink=669>.

[430] <Cyberlink=617>.

[431] <Cyberlink=670>.

[432] The exceptions are, again, to be found in the Internet law-related areas, such as the Journal of Information, Law and Technology (<Cyberlink=616>).

[433] Apart from some early CD-ROM databases in hypertext format, e.g. on the Treaty establishing the European Economic Area.

[434] There is, for instance, a widely used syllabus (E-book) on Internet law by a German professor (<Cyberlink=671>).

3.3 Cross-disciplinary comparison: the status quo

Based on the details, examples and individual assessments given under the previous heading (3.2) in the form of case studies, this section gives a comparative overview on the status quo of "cyberness" in the (sub-)disciplines included in this study. The empirical evidence is presented and analysed in aggregate form.

3.3.1 E-mail as standard communication channel

Data from the mid 1990s already suggest widespread use of E-mail across all disciplines. This rapidly expanding trend (OECD 1998, 192) suggests that by now, access to the Internet should be nearly 100 per cent in all fields, at least in the so-called "developed" world. To be sure, there are still a significant number of regions in the world where access to the Internet is not as widely available as in the West, in particular in parts of Eastern Europe, Africa, Latin America and Asia. Consequently, E-mail use there (though often the first Internet application available) is not directly comparable with the general results presented here, as they are based on our knowledge of academia in the Western civilisation.[435]

Indeed, there is almost no field in my sample where E-mail is not used widely. Only the respondents in parts of philosophy and language studies were hesitant and acknowledged that a higher proportion of the more senior people in the field do not yet use E-mail as a standard communication channel. By contrast, the interviewees from many of the three science sub-disciplines in the sample, but partly also in economics, mathematics and anthropology felt that *all* researchers used E-mail without any significant exception. Even in those areas where E-mail is not used by all, there seems to be a strong trend towards universality. Just like nowadays the phone and the computer are tools present in all researchers' offices, we may expect this to happen soon with E-mail as well.

Table 3-2: E-mail use[436]

		LAN[S] PHIL[A]	ANTH[L] PHIL[R] PHY[H, F] LAW[I, E, T] MED[C, I] ECO[P, R] BIO[M] POL PAP LAN[L, C] MATH[C, N] HIST[E, A, P] SOC[E, S, T]	PHY[S] MED[N, T] ANTH[P] ECO[E, M] BIO[B, O, E] MATH[K]
used by almost nobody	*used by a small minority*	*used by more than a minority*	*used widely*	*used by almost all*

Among the rapidly decreasing minority of researchers in all fields who do not use E-mail personally, many nevertheless have an E-mail address since this comes almost automatically with a job at university. Some of these addresses are not used at all, but secretarial staff takes care of the majority. In the latter case, E-mail is just another delivery

[435] This issue, often discussed under the label of the "digital divide", is treated elsewhere in this study (see chapter 4.3.4.1).

[436] For a legend of the abbreviations used in this and the following tables see Table 3-1 above.

channel for mail. It is treated just like a fax or normal letter. The secretary prints out the E-mail for the professor who acts upon it comparable to other mail. Now and then, the answer to such an E-mail is not even given by E-mail but through other channels, such as a phone call or a normal letter. But this is the exception and according to my respondents, this minority is ever more marginalised. There seem to be many examples of researchers who, after some years of total neglect, have recently discovered the benefits of E-mail. Note that this minority is not only composed of elderly professors: across all fields, there are also a few examples of younger researchers who do not use E-mail, next to most senior researchers who do.

In most circumstances, E-mail has replaced letters and faxes. E-mail is considered by the respondents of all fields as an advisable communication channel for *contacting people*, even for first-time contacts. Most researchers first try to get in contact with each other by E-mail. They use other channels only in case of failure, i.e. if no response is received within a reasonable amount of time (perhaps 2-3 days), and often only if a second try is not successful either. Only in philosophy (where, as I have noted above, E-mail is still less widely spread) do we see that first contacts are still often done through a formal letter. This is certainly also true for special occasions depending on status and purpose of communication in all other fields, but the evidence shows that E-mail has taken over in all standard situations.

While by no means a representative sample, the figures given by the 50 interviewees regarding their *personal E-mail use* are nevertheless a good indication. My researchers have received between zero and even up to 120 E-mails a day. The latter extreme is due to the fact that a number of researchers were included in the sample who also served as webmasters. Those editing a journal or having high numbers of students (who are increasingly "on E-mail" and who do not hesitate to contact the teachers directly, see 5.2) also have higher numbers of incoming E-mails. The average in my small sample is at about 20-30 E-mails per day. Smaller figures were reported by the sciences, rather higher ones from the respondents in the social sciences and humanities. For sure, the number of daily E-mails is not constant, depending on project phase or point of time in the university term.

The answers regarding *personal phone and fax use* are very diverse: some researchers seem not to phone at all, others still do it frequently. In my sample, only sociologists uniformly seem to phone a lot, whereas historians and economists uniformly seldom call. However, even those who answered that they had several phone calls per day said that they phone much less than previously and made a direct connection to increased E-mail use. The same is true for fax use, which is also decreasing. Again, the individual preferences and habits seem to play a role. Only mathematicians and biologists seem to uniformly seldom use the fax. The main purpose for fax use is the sending of forms where hand-written signatures are necessary. Another example is the sending of proofs with corrections at the margins.

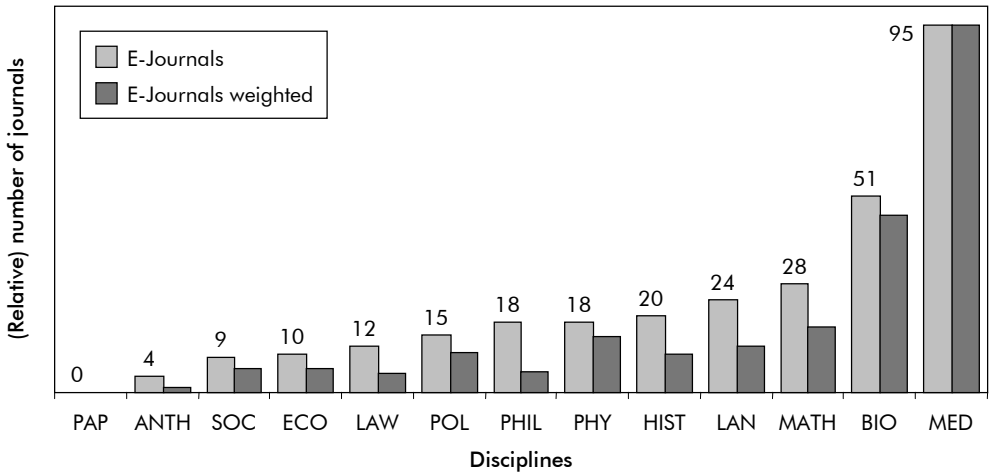
E-mail is used for almost all *purposes* of communication: among scientists, between them and administrative staff, with students, with outside bodies (like funding agencies), other experts and partly also lay people. Focusing on the communication among the researchers, the main thrust of E-mails seems to be devoted to organisational issues. This includes project management, conference organisation, correspondence with editors and publishers and day-to-day organisational business like co-ordinating meetings or arranging travel. While E-mail use for these purposes is universal, content-related discussion by E-mail strongly depends on personal preferences. Exchanging arguments in the main body of the E-mail is, in any case, less frequent than using attachments for sending drafts

of co-authored papers. In some fields, this is due to difficulties of representation of the technical language (e.g. in mathematics) or the fonts (e.g. in Slavic studies where Cyrillic letters are necessary). For the larger part, it seems a matter of convention and preference. The editing function of MICROSOFT WORD, which allows for version tracking and structured co-authoring, is not known to all interviewees.

To sum up, E-mail has become the standard communication channel among researchers, for practically all purposes.

3.3.2 E-journals fighting for recognition

One of the key cyber-applications are pure E-journals, i.e. academic journals which are published online only – as compared to journals which mainly appear in print and have or have not an online companion or online version. On a general level, pure E-journals were not widespread in most fields included in this study. The interviewees were not aware of E-journals in anthropology and in papyrology, and only of very few in sociology and economics. By contrast, they named some fields where there are quite many already in linguistics, mathematics and history. However, as in-depth knowledge about the spread of E-journals does not seem to be distributed widely, not even among the scholars interviewed in this study, the data generated by the interviews had to be amended and partially corrected. This was computed on the basis of a worldwide database of E-journals, the Directory of Scholarly Electronic Journals (DSEJ), 1st edition[437], November 2000, see Figure 3-1:



Source: Amended and re-computed data from DSEJ 2000

Legend: Absolute numbers represented as light bars, relative (weighted) numbers as dark bars; the figures given are the absolute numbers from the DSEJ

Figure 3-1: E-only journals in a few disciplines

[437] The DSEJ 1st edition (<Cyberlink=180>) succeeded the 7th edition of the ARL directory of Electronic Journals, Newsletters and Academic Discussion Lists (<Cyberlink=146>).

The DSEJ data reveals that the highest absolute numbers of genuine E-journals exists in medicine and molecular biology. Even in anthropology, where the interviewees were not aware of any E-journal, the DSEJ editors counted four. These differences in perception are probably due to a geographical bias. DSEJ is compiled in the U.S., but the interviewees, although experts with international experience were based in Europe. Furthermore, knowledge of the existence of E-journals can also be seen as an indirect indication of the esteem of E-journals in general in that field, see below.[438]

In Figure 3-1 above, I included the absolute numbers of E-journals in each discipline (blue/light bars) as well as a relative measure (red/dark bars), computed as the product of the absolute number and a specific weight which indicates the relative size of the specific community.[439] From this we can see that the two ends of the ranking do not change whatever measure we take (relative or absolute). This means that the life sciences are still at the top end, papyrology[440] and anthropology at the bottom end. However, given the relative size of physics and mathematics, as well as political science, these three disciplines would rank higher than if we only look at the absolute figures.

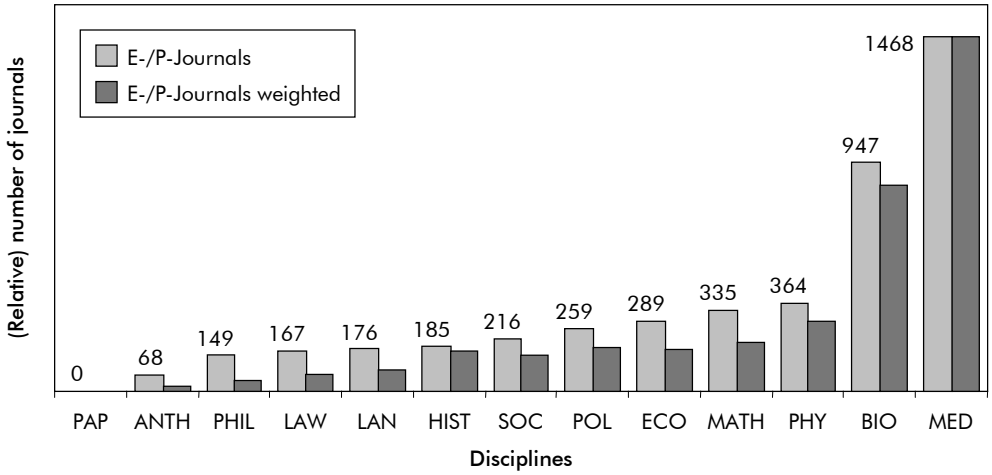
The ranking looks quite similar if we look at the total number of electronically available journals, i.e. not only those which appear online-only, but also include those paper journals which offer the full text of their articles in addition via WWW (see Figure 3-2, below). While the top and bottom ends of the ranking are identical, there are a few remarkable differences between E-only-journals and P-/E-journals (parallel journals): In those disciplines where there are relatively many parallel journals, there are relatively fewer E-only-journals (physics, economics, political science, sociology). Vice-versa, in those fields where only few print journals went online, the relative proportion of genuine E-journals is much higher (philosophy, law, language studies, history). From this we can infer that the respective research communities were rather deterred to duplicate or compete with the electronic versions of well-established P-journals with E-only-journals. Vice-versa, there is a higher incentive to found innovative journals in areas where the traditional media are less innovative. In the latter case, there were fewer counter-forces at work that would have hindered the market entry of the new E-journals. To be sure, this

[438] Note however that the DSEJ is intended to be a comprehensive directory, totally independent from esteem. It may be that a few journals have slipped the attention of the editors, but we can take the numbers given as a very good indication of the real numbers at this point in time. Furthermore, the DSEJ is, unfortunately, not precise enough as to differentiate between mono-disciplinary and interdisciplinary journals.

[439] It was all but easy to compute reasonable weights to account for the different overall sizes of the disciplines as there are no univocal and all-encompassing statistics comparing the various disciplines. Furthermore, the respective answers of my interview experts were too unspecific to easily form the basis of a comparison. I finally used as a proxy the number of authors from each discipline in the databases of the Institute of Scientific Investigation (ISI <Cyberlink=488>). See also 3.4.1 and Table A-4 in Annex I. The following weights were used: PAP: 0.1; ANTH: 0.3; PHIL: 0.3; LAW: 0.4; HIST: 0.5; LAN: 0.5; MATH: 0.6; ECO: 0.6; SOC: 0.7; POL: 0.7; PHY: 0.8; BIO: 0.9; MED: 1.0. Note, that this is nevertheless no adequate representation of the actual relations in size for instance, there are not only 10 times more medical researchers than papyrologists and also the relation between biologists and mathematicians is certainly not exactly 2:3. However, I submit that these weights – how imprecise ever – help us grasp the reality a bit better than simply comparing absolute figures. We have to keep in mind that these comparisons are only the basis of a qualitative argument.

[440] Note that papyrology, as already discussed in 3.2.1.4, is hardly representative for classical studies as a whole, and cannot count as a true discipline in its own right (although some papyrologists would say so), in particular if we compare it in size with all other disciplines listed above, including the second smallest discipline.

is also a matter of timing. As there is a forceful trend towards parallel publication (print and electronic) in all areas, many of those specialities in which there is no P+E-journal yet will soon have one. Thus the time slot for the foundation of E-only journals might be closing. However, parallel journals might become E-only in the not so distant future (see 7.3.1.4).



Source: Amended and re-computed data from DSEJ 2000

Legend: Absolute numbers represented as light bars, relative (weighted) numbers as dark bars; the figures given are the absolute numbers from the DSEJ

Figure 3-2: Electronically available journals (E-only and P+E-journals) in a few disciplines

To some extent, the high figures of E-only journals in the life sciences (biology and medicine) are astonishing, as they seem to contradict the above hypothesis. Why are there so many E-only journals in fields with a large amount of parallel publications? Three possible hypotheses are conceivable. First, the E-journals are already older than the parallel publications (and the mainly commercial publishers of the traditional P-journals did not mind the competition of the existing online journals). Note, however, that the Bio-Med initiative recently generated a growing number of E-series in opposition to the established journals. Another hypothesis, namely that the numbers are only big in absolute terms, but not relative to the overall size of the community, cannot be sustained. If we weigh the figures (see above and fn. 439), the resulting ranking is identical. A third hypothesis is that the large number is mainly due to the enormous overall figure of academic journals in the life sciences as a whole. Note also that the differentiation and specialisation in the life sciences is very high already and still increasing. So perhaps (I cannot show this empirically here) the E-only journals are niche products in the sense that they serve a very specialised scientific community. Alternatively, they may be the first journals in newly arising areas where no established P-journal previously existed.

When it comes to assessing the prestige of E-journals, my experts showed considerable differences.[441] At average, the prestige is quite low. There are a few fields where E-journals already seem more established, for instance in some parts of mathematics (e.g. K-theory) and in a special sub-field of philosophy (risk analysis), see Table 3-3:

Table 3-3: Prestige of E-journals

PAP SOC[S]	SOC[E, T] PHY[F, S] LAN[S] ANTH[L, P] BIO[M, B, O, E] PHIL[A] MATH[C] MED[C, I, T] ECO[P, E, M, R] LAW[E, T]	POL HIST[E, P] MED[N] LAN[L]	PHY[H] MATH[N] LAN[C] LAW[I] HIST[A]	PHIL[R] MATH[K]
(E-j. non existent)	*low*	*low, but growing*	*medium*	*high*

Prestige of a journal is mainly a composite of (1) whether articles from that journal are quoted in other journals, (2) whether they are credited in evaluation and promotion procedures, (3) whether the journal has a rigorous quality control system (refereeing) and (4) of a more general esteem factor rooted in the prestige of the editors and authors as well as the publisher. In my sample of interviewees, in all but five disciplines (anthropology, papyrology, physics, biology, sociology) I found people who had already published in E-journals. However, only few thought of these publications as important personal achievements. Where the prestige was considered rather low, the main reasons were a refereeing procedure known to be sloppy or not known at all (dubious), and the fact that the high-ranking, most senior researchers in the field chose not to publish in that E-journal. In those sub-disciplines where the rating of a journal plays an important role for an author's decision to which journal s/he submits (in particular the natural sciences, but also for instance in economics), E-journals play a more restricted role. This is because they are often not yet included in the large citation databases that form the basis of this rating (e.g. the Science Citation Index etc.).

On a whole, although quite significant numbers of E-journals already exist, they are by far outnumbered by so-called parallel publications, i.e. those who are published both in print and online. The prestige of E-only publications is in most cases rather low, but often growing. Only in a few areas do E-journals seem to be an already established channel of scholarly communication. It seems conceivable that in the case of E-journals (as well as, for instance, in the case of E-conferencing) strong network effects are at work. The E-publishing system can be regarded as a formal communication network whose benefit for the users increases with its size. Therefore, we may expect that the more E-journals there are, the more will follow and the higher their prestige will rise (cf. the notion of "interactive technology", introduced in 1.2.3.5).

[441] Never completed nor even started has been the ambitious research proposal by McEldowney (1995) who planned a major survey with questionnaires to find out about what "the factors which affect acceptance or resistance toward electronic journals among academics" are and whether there is a difference between disciplines in relation to these factors of acceptance or resistance.

3.3.3 The early days of hyper/multimedia applications

As discussed in more depth in chapter 6, E-publishing can be more than only a new delivery channel for texts, as we know them today. For instance, electronic hypertexts or hyper-multimedia applications such as video-clips, audio-files or interactive picture databases may be genuine academic output. Also numeric data files with software to compute the results included or appended to E-publications might be a novel format. All of these new types of publications are not yet common in most disciplines. Such innovative applications seem well established only in biology and history – although even in these fields we can only speak of "relatively many" applications. I did not find any such examples in three fields (papyrology, law, European studies). For a comparison see the following table.

Table 3-4: Spread of hyper/multimedia

LAW[I, E, T] MED[T] LAN[S, C] ANTH[L] PAP POL SOC[T] BIO[E] PHY[F] ECO[P, E] MATH[C, K]	SOC[E, S] ECO[R] PHIL[A] ANTH[P]	BIO[M] ECO[M] PHY[H, S] MATH[N] MED[C, N, I] LAN[L] PHIL[R]	BIO[B, O] HIST[E, A, P]
none	*isolated examples*	*some*	*relatively many*

Many interviewees, however, reported some potential for more sophisticated publications in their field. For instance, anthropologist and other cultural scientists work with pictures, film and audio recordings, which are all apt for inclusion in a hypermedia environment. Papyrologists, although well advanced with respect to the use of worldwide text databases, are not yet publishing electronically; as they are also working with photographs (or scans), there is a chance that they might include multimedia elements besides text. In the life sciences and partly in physics, the parallel online publication may be "enhanced" as compared to the printed version. The electronic annex often includes more or coloured pictures, video-clips or data sets that could not have been published in print.

Genuine hypertext has not yet been produced at any significant level by any discipline. History is most advanced so far. Historians are compiling huge archives of primary sources in electronic format and making them accessible via WWW homepages using deep hypertext structures.[442] Apart from history, there are only a few rather isolated projects, e.g. in physics.[443] Some literature scientists are dealing with hypertext fiction, but they are not writing hypertext themselves. Hypertext in the sense of extensive use of hyperlinks in electronic publications (mainly E-journals), by contrast, is already well established in some fields. In particular, the CROSSREF[444] initiative aims at automatically generating cross-hyperlinks between the bibliographies of scientific articles and the full text of the quoted literature. Other journals, such as Living Reviews in Relativity[445] build up an extensive internal database from the reviewed articles. In addition, most of those E-

[442] E.g. the Valley of Shadow database <Cyberlink=295>.
[443] Most notably the studies of the Van der Waals-Zeeman Laboratory, see 3.2.3.1.
[444] <Cyberlink=376>.
[445] <Cyberlink=237>.

journals which are not published in PDF or Word formats, but in HTML, extensively use internal (to the various sections of the article) and external hyperlinks (to outside sources).

In sum, while hypertext is almost unknown in most fields (except for its simple use on homepages and link collections), academic knowledge representation with multimedia elements is already more widespread (for a discussion of the potentials and chances of both publication enhancements, see chapter 6).

3.3.4 E-conferencing only in exceptional cases

Electronic conferencing, be it with or without video transmissions, is rather exceptional in all disciplines. Except for some fields in medicine, physics, sociology and history, only experimental events were reported in the interviews. High-energy physicists use video-conferencing, i.e. a telephone and satellite-based service, and North-American historians use Internet-based E-conferencing on an almost regular basis (see Table 3-5).

Table 3-5: Spread of E-conferencing

SOC[E, S] BIO[B, O, E] HIST[E] PAP ECO[P, E, M, R] PHY[D, S] MATH[C, K] MED[I, T] LAN[S, L] PHIL[R, A] ANTH[L, P] LAW[I, T]	POL HIST[P] LAN[C] LAW[E]	SOC[T] BIO[M] MATH[K] MED[C, N]	PHY[H] HIST[A]
none	*isolated examples*	*some*	*regular use*

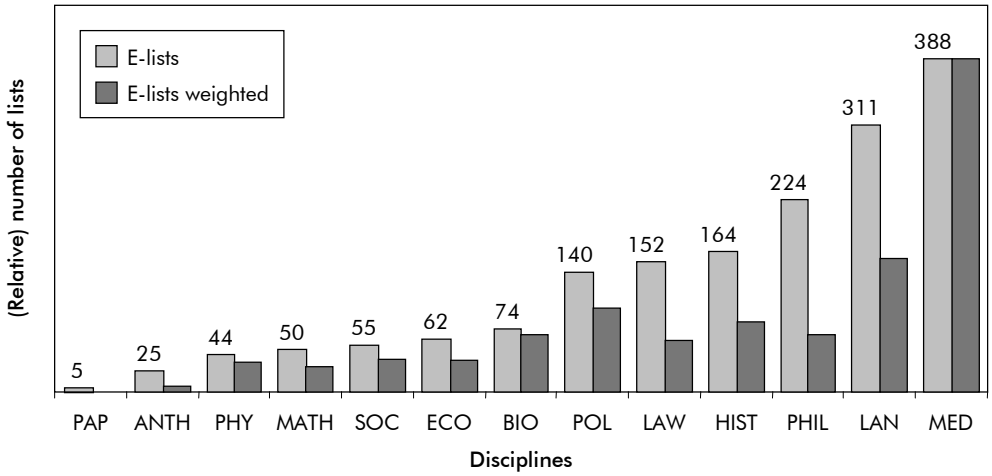
In medicine, it was reported that conferences increasingly offer online access to parts of the conference via live streaming. These conferences are sponsored by the pharmaceutical industry and have, nevertheless, a physical venue. In most cases these are not synchronous and interactive, but the remote auditorium has the opportunity to "post comments" by E-mail or through a web-form which will later be added to the respective page of the conference website. Asynchronity and only partial interactivity seem to be the case in those other disciplines with at least some online events, too. Most personal experiences with some sort of web-cam-based communication took place in connection with tele-teaching experiments or in the private domain.

The most frequent reason given in the interviews for this state of affairs is that most academics love to travel and do not want to miss the "other side" of meetings, i.e. the opportunity for socialising, for making new contacts etc. At the same time, the respondents pointed at decreasing travel budgets and hence saw some real potential for E-services use in smaller workshop-like project meetings – while still acknowledging that the use of phone, in most cases, is a good alternative to meeting in person. Furthermore, the interviewees often pointed at the (still) poor quality of Internet-based "net-meetings" coupled with the (still) high prices of both the infrastructure and the telecommunication fees for the available professional video-conferencing services.

All in all, except for some rare examples, E-conferencing is not an issue yet in academia. The reasons seem to be both technical and cultural (see 4.2.2.2 for an in-depth discussion).

3.3.5 Importance of E-lists varies

E-mail-based lists are very widespread in all disciplines (see Figure 3-3). Even the tiny sub-discipline of (non-Arabic) papyrologists has one (highly frequented) general and a few more specialised lists for community communication. Usenet newsgroups (where you do not get the messages as E-mails directly but where you have to actively scan and download messages posted to the group from a special site on the Internet) seem to be less popular among academics. None of my interviewees reported regularly consulting, not to mention participating in, such newsgroups.



Source: *Amended and re-computed data from DSEJ 2000*[446]

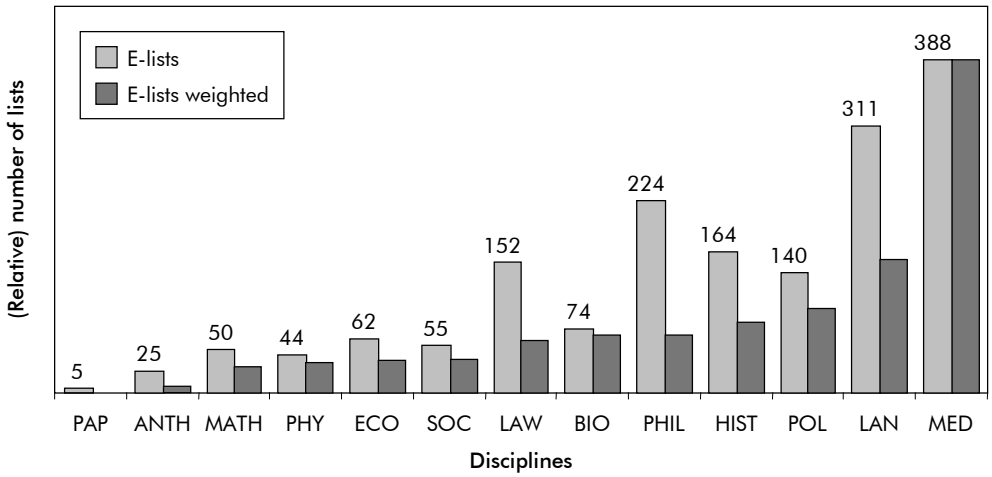
Legend: *Absolute numbers represented as light bars, relative (weighted) numbers as dark bars; the figures given are the absolute numbers from the DSEJ*

Figure 3-3: Spread of E-mail lists in selected disciplines, sorted by absolute numbers

The highest number of lists is again to be found in medicine, probably due to the high degree of specialisation noted above which makes it necessary to found ever more specialised forums. Interestingly, other life scientists seem to use lists far less frequently. One hypothesis to explain this is that molecular/micro biology is even more competitive than medicine. Ranked second we find the humanities, in particular language studies, philosophy and history; then come law and political science. All these are disciplines where the scholars rather work alone or in very small groups, but generally not in teams. Perhaps communicating via lists somehow compensates for missing opportunities of communication in more collaborative settings. At least for history, law and political science, another factor might also contribute to the relative popularity of lists. Lists prove to be highly efficient tools for quick factual queries, e.g. for locating a particular court judgement, a particular date or person or perhaps the meaning of a strange abbreviation.

[446] Note again that the DSEJ data is not distinguishing between mono-disciplinary and interdisciplinary lists (see already fn. 438 for E-journals).

Note that unlike in the case of E-journals, the weighting of the numbers of lists actually changes the ranking, though not profoundly (see Figure 3-4): law has relatively fewer lists while political science and philosophy have relatively more.



Source: *Amended and re-computed data from DSEJ 2000*

Legend: *Absolute numbers represented as light bars, relative (weighted) numbers as dark bars; the figures given are the absolute numbers from the DSEJ*

Figure 3-4: Spread of electronic discussion lists in selected disciplines, sorted by relative numbers

Individual preferences with regard to E-mail lists are very diverse. Some had subscribed, but soon "un-subscribed" when flooded with too many E-mails per day. Another reason for leaving lists often is when it turns out that it takes too much time to scan the incoming messages in search for valuable pieces of information. Others, probably the majority, are so-called "lurkers", i.e. still on the lists, but not actively participating in the exchange of information or discussion. Only a minority of subscribers actually shapes what is going on in the lists by posting messages.

The assessment of the importance of the lists (see Table 3-6) is not uniform throughout and even within the disciplines. Only the respondents from papyrology, European studies and sociology uniformly considered their lists to be active and important for their work. In all other disciplines, the opinions were split. In North-American history, fluorescence analysis and papyrology, the lists have been rated very important. Only the experts in six out of 36 sub-disciplines considered the existing lists in their fields not important. Some interviewees said that the relative importance of being on such lists varies according to status and point of career. If you are searching for a first or new job, being connected to such an information channel is more of an issue than if you get any piece of information you need directly and immediately because of your academic status.

Table 3-6: Perceived importance of E-mail lists

MED[I] LAN[S] ECO[P, E] MATH[C, N]	BIO[B, E] HIST[P] ECO[M, R] PHY[S] MED[T] PHIL[A] ANTH[P] LAW[I, E]	MED[C, N] LAN[L, C] PHIL[R] ANTH[L] LAW[T] HIST[E] PHY[H] MATH[K] POL SOC[E, S, T] BIO[M, O]	HIST[A] PHY[F] PAP
not important	*not too important*	*important*	*very important*

On average, the researchers in my sample had subscribed to four lists, the range stretching from zero to twenty. The large majority of these lists were of the "distribution list" type, i.e. sending around information. While some of those lists are "democratic" in the sense that everyone is allowed to post messages (e.g. book announcements or workshop invitations), often these lists are one-way channels of a particular scholarly association which regularly sends out information, e.g. in the form of newsletters.

Only a minority were genuine discussion lists with messages by – potentially – all subscribers. Such lists are to be found, in my sample, in seven sub-disciplines (microbiology, analytical philosophy, thorax anaesthesia, neurology, papyrology, North-American history and quantitative archaeology). As I cannot detect any obvious commonality among these sub-disciplines (they belong to the humanities and the life sciences, but are rather diverse), I suspect that my sample is too small to allow any conclusions. In general, the more active lists among those are closely connected to particular collaborative projects. In the more general ones, you would find mostly "question and answer" type messages. Furthermore, some of the distribution lists undergo a metamorphosis from time to time and experience intense periods of discussion before going back to the usual mode.

I have also asked how the researchers deal with incoming messages from lists. The result is that most people read at least the subject headings of incoming messages immediately, that is they do not automatically filter the list messages out and store them in specific mail folders for later reading. After this first screening of headings, messages will either be trashed immediately or read in full.

Summing up, we can conclude that E-mail lists are widespread and present in all disciplines. It is mainly the informational value that makes them useful to a majority of sub-disciplines, and less being a forum of genuine discussion.

3.3.6 E-(pre-)print servers established in some fields

Pre-prints (working papers) do not play an important role in all disciplines.[447] As Becher (1989, 81) argues, pre-prints are mainly known in what he calls "urban" research specialities, i.e. those which are more competitive, denser "populated", more teamwork-oriented. Accordingly, E-pre-print servers are not present everywhere. In Table 3-7 I mapped the expert answers given to three different questions. On the x-axis, I spread the assessment of the importance of pre-publications in the respective sub-discipline. This dimension has four values: not important, medium, important and very important. On the y-axis, an estimate of the number of papers which are published in journals and/or books

[447] For instance, in 1994 at least, pre-prints were almost unknown in chemistry (Odlyzko 1994, 25). Trying to explain this difference if compared to physics or mathematics, Odlyzko argues that the latter fields have extremely rapid publication rates with superficial refereeing.

and which have been previously circulated as a pre-publication, e.g. a working paper, is given. I distinguish between fields where all, most, about half, some, only a few or no pre-publications exist. Furthermore, those sub-disciplines with an electronic pre-print server are highlighted in bold letters.

Table 3-7: Status of pre-publications versus number of (grey) pre-publications

Number of pre-publications	not important	medium	important	very important
all			**ECO**^{M} **PHY**^{H} **MATH**^{K}	**ECO**^{P}
most		**ECO**^{R}	SOC^{T}	**ECO**^{E}
half		**LAN**^{L}	**MATH**^{N}	
some	MATH^{C} LAW^{E} SOC$^{E, S}$	**POL** PHIL$^{R, A}$		
few	HIST$^{E, A}$ PHY^{S} ANTH$^{L, P}$			
none	BIO$^{M, B, O, E}$ MED$^{C, N, I, T}$ PAP LAW$^{I, T}$ PHY^{F} LAN$^{S, C}$ HIST^{P}			
	Pre-print culture			

Legend: The disciplines in **BOLD** *are those with an E-pre-print server, those* UNDERLINED *are central archives.*

With a single exception, we also find E-pre-print servers in all those fields where at least half of the published papers already existed in a pre-print version and where the pre-print culture is rated at least of medium importance. The outlier is social science studies of technology (SOC^{T}) where there seems to be an important pre-print culture with most papers pre-published, but nevertheless no pre-print server. The likely explanation is that in this field researchers come from many institutional and disciplinary backgrounds with only loosely developed scholarly associations. As a consequence, working papers are still archived in many different locations. We may hypothesise that no E-activist has yet taken the initiative, as is the case in all other fields with such a server. And indeed, in all fields, but this one, the experts could name "cyber-entrepreneurs" (cf. SOC^{T} in Table 3-23 under heading 3.4.5.1). Given this general trend, it is therefore to be expected that such an archive will also be established in this field sooner or later.[448]

As presented elsewhere in this study (see 2.3.2), archives come in two flavours, One option is that they are central repositories to which researchers directly upload their files.

[448] Not yet well known and used in Europe is the SSRN eLibrary (<Cyberlink=237>) which allows for uploading of papers by individuals (alongside traditional publishers). Here all submitted papers are forwarded to subject editors of so-called "journals" which collect and publish the abstracts of the submitted papers. In some respect, SSRN is an equivalent to an E-pre-print server.

The alternative is that they are de-centrally organised meta-search-engines that allow users to search and access the papers via a central interface while the papers are stored decentrally on the servers of research institutes. In the sample of the sub-disciplines I analyse here, both types are present. While a central archive has been established in high-energy physics and K-theory, de-central solutions have been implemented in all other fields.

To sum up, E-print archives exist in all those sub-disciplines where a high proportion of academic papers are circulated in advance of formal publication and where this system of pre-publication is an important part of this field's culture. Obviously, the advantages of an electronic distribution system – as compared to sending around pre-prints – were convincing.

3.3.7 Disciplinary databases as a standard tool

"Database" has become a buzzword in almost every field. There are not only databases for numeric data, but also for text, pictures, software etc. I asked for (sub-)discipline-specific databases, i.e. those which serve, in particular, this specific community. The findings indicate that only very few fields do not have one (ethics, cardiology, thorax anaesthesia).

Table 3-8: Spread of disciplinary databases

	SOC[E, T] HIST[P]	SOC[S] BIO[M, B, O, E] HIST[E, A]
	ECO[R] PHY[F] MATH[C, K, N]	POL ECO[P, E, M] PHY[H, S] PAP
MED[C, T] PHIL[R]	MED[I] LAN[S, C] ANTH[P] PHIL[A]	MED[N] LAN[L] ANTH[L] LAW[I, E, T]
none	*some*	*many*

In some fields, databases have become central. For instance, in molecular/micro biology the various gene sequence databases are an essential tool for every researcher: The results of a whole field are stored in these online accessible databases worldwide. The same is true for papyrology where the edited transcriptions of all papyri are searchable for the whole community. Databases collecting legal texts of all kinds, such as statutes, judgements, directives have great importance for legal scholars in their daily work. In European studies, various (official) databases support research, but there are not many generated by the researchers themselves.

Much of the information that has been stored in linear form (e.g. lists) up to now lends itself to conversion into databases and consequently ever more databases are being produced. In particular, information stored on institutional homepages such as publications, projects, personnel etc. is increasingly being fed into databases for the creation of dynamic webpages.[449]

All in all, databases of various types are widespread, have become a standard tool in most fields and are still gaining in importance.[450]

[449] As opposed to static webpages which always show the same content as long as they are not edited manually, dynamic webpages are generated on the basis of the potentially changing content of databases. To name just one example, if the contact information of a new staff member is stored in a database, this information can be automatically inserted in all pages related to this person (e.g. projects, bibliographies).

[450] Earlier studies on the use of online bibliographic databases in various disciplines (U.K.) are presented in (David/Zeitlyn 1996; Mann 1998).

3.3.8 Digital libraries spreading

The notion of a digital library is neither precise nor well defined, so everyone has a different concept in mind when asked whether a digital library exists in the field. The very basic level is the bibliographic database, i.e. a database with meta-information (author, title, source etc. but no full text) of all relevant academic literature. Almost every field has a "digital library" in this sense as most real libraries have uploaded the meta-information about their holdings to a database. In most cases, this database is also accessible online via the Internet and hence available for the individual researcher without actually having to visit the library. Even on this basic level, however, not all sub-disciplines have such a library, which would be useful for the everyday work of a researcher. In particular those disciplines that rely on literature older than about twenty years (e.g. literature studies, cf. Table 3-21) will not find these older books in the database in all cases because many libraries did not have the means to convert all old library index cards into the new electronic format. Furthermore, the individual articles in edited books or the articles in (older) journals are often not individually covered by these databases. Therefore, most library OPACs cannot be said to be comprehensive "digital" libraries.

In any case, these bibliographic databases – even if very comprehensive – do not provide electronic access to the full texts of the items in the database. A library's function is to enable access to full texts, hence a real digital library would have to enable access to electronic versions of full texts.

In this respect, those sub-disciplines which rely less on books and more on journal articles (cf. Table 3-21) have an advantage – and even more so if the most recent articles are more important for research than older ones. Journal publishers have increasingly uploaded the full texts of the articles published in their journals to their websites. As we have seen in the section on the spread of electronic journals (above 3.3.2), the life sciences, physics and mathematics have the highest figure of such combined P+E-journals. If a researcher sits in an institution which can afford the often very high licensing fees for all journals necessary for this research, then the large databases of the publishers (e.g. Springer, Elsevier) or, even better, the combined databases (e.g. OVID[451], PubMed[452]) can be said to be true digital libraries. In the latest versions of these databases even the entries of an article's bibliography are electronically linked to the full text of the quoted articles. Although researchers will not find books in full text or older articles or chapters of books in these databases, they are nevertheless in command of a very powerful digital library. This is, however, not yet the case in many disciplines, in particular not in the humanities: "In disciplines where research is published predominantly in journals and knowledge has a short shelf-life, as in the sciences and many social sciences, we are very rapidly approaching an environment in which most of the relevant literature is part of a digital archive .... Scholarship in the humanities is not yet near this situation." (Mueller 2000a, 7)

Another form of digital library is the so-called virtual library (VL). There is a central VL site[453] that links to a great variety of such libraries in almost every field of interest (not only academic). While some of these VL sites are genuine access points to structured collections of full text information in the web, most are rather link collections, portals and

[451] <Cyberlink=704>.
[452] <Cyberlink=625>.
[453] <Cyberlink=603>.

gateways. They are certainly helpful tools if you want to search for information that you believe to be somewhere on the Internet in a structured way. However, full text access is only rarely the case. These sites are, however, not too well known in the academic world, except for "Project Gutenberg", the large collection of classic texts from the literature.

Acknowledging this situation of unclear definitions, it is nevertheless informative to see the answers of the experts of the various sub-disciplines included in this study about whether or not they feel that "a digital library" indeed exists:

Table 3-9: Answers with regard to the existence of digital libraries

HIST[P] ECO[P, E, R] PHY[H, F] MATH[C, N] PAP LAN[S] ANTH[L]	POL SOC[E, S, T]	ECO[M] LAN[L, C] PHIL[A]	MED[C, N, I, T] PHY[S] MATH[K] BIO[M, B, O, E] HIST[E, A] PHIL[R] ANTH[P] LAW[I, E, T]
no	*rather no*	*rather yes*	*yes*

Table 3-9 clearly indicates that different notions of digital library were at work, therefore the answers are partially misleading. On the one hand, all physicists and most economists for instance have full text access to all journals, but some of the experts did not count this as a digital library. On the other hand, the respondents from the life sciences clearly had the database PubMed in mind when they answered in the affirmative. Whatever definition we take, legal scholars have a gigantic digital library at their disposal nowadays: in many countries central full text databases are available which include all sorts of texts a lawyer might need (see already above in 3.3.7).

To sum up, in those fields (mainly in the natural sciences) where a large proportion of the journal literature is already available online, we can already speak of digital libraries *in statu nascendi*. In those where (also older) books play an important role, only the beginnings of electronic libraries in the form of link collections (so-called "virtual libraries") are to be found.

3.3.9 Groupware not yet well-known

In many academic fields, co-operative working at distance is done on a daily basis and groupware is specialised software to facilitate this. With the exception of three sub-disciplines in my sample, however, such tools are not used. Even in those three, the expert answer was "sometimes". In short, we cannot speak of regular use. The exceptions are the social science studies of technology, molecular oncology and high-energy physics. If we look at the sample of 50 researchers, some of them reported that they have at least a bit of experience with groupware: in addition to the fields just listed the experienced came from regional economics, theoretical physics, applied linguistics, analytical philosophy, Pacific studies, information law and tax law. Most interviewees did not even know the term groupware.

However, this status quo is probably hiding a different underlying reality. E-mail with attachments, as well as common access to dedicated directories on the institute's file server (e.g. in a WINDOWSNT or NOVELL network or with open FTP servers) which basically allows exchanging and accessing common files, in some cases even simultaneously, are

quite common for many researchers. Hence there is already a lot of co-operation going on in science and research with the help of electronic means. It is simply not known as "groupware", and less sophisticatedly organised. Furthermore, it seems, that proper groupware is increasingly used in international and interdisciplinary projects, e.g. within the EU research framework.

3.3.10 Growing number of virtual institutes and extended research groups

While extended research groups work together on the basis of ICT (E-conferencing, groupware, E-mail, E-lists) for a single or a series of projects, virtual institutes go one step further by establishing some sort of institutional infrastructure stretching beyond projects, and collaboratories provide for remote access to laboratories. All three forms have in common that they are (looser or denser) organisations which have no, or only a very small, home base in the real world while mainly existing as a network of researchers who are based in many different locations. The experts of many fields did not even know the concept of virtual institutes etc., but there are nevertheless already a few genuine examples.

Table 3-10: Spread of virtual institutes

PHIL[R, A] PHY[F, S] ANTH[L, P] MED[C, N, T] SOC[E, S] BIO[M, B, O, E] LAN[S] HIST[E, P] LAW[E, T] MATH[C, K, N] PAP ECO[R]	PHY[H]	POL HIST[A] SOC[T] LAN[L] LAW[I]	LAN[C] ECO[P, E, M] MED[I]
none	*stable project networks*	*beginning virtualisation*	*virtual institutes*

The best examples so far of virtual institutes in my sample of sub-disciplines are to be found in cultural studies and in economics. Furthermore, there are examples of collaboratories in the medical sector, e.g. AIDS research. In five other areas, the experts reported beginnings of such virtual entities (European studies, North-American history, technology studies, applied linguistics and IT law). Note that the funding agencies, in particular but not only the European Commission, are increasingly asking that project websites feature interim results and facilitate group communication. We may call these project networks, or "extended work groups" (cf. 4.1), an early stage of virtual institute as they become extended to successive projects with a continued presence and virtual organisation in the Internet, e.g. in high-energy physics. In the science sub-disciplines under closer inspection here, I did not find any genuine example of a collaboratory: not even the high-energy physicists work at distance with the CERN facilities when they are at their home institutes. They download files from the CERN servers instead in order to work with them in their home offices and they travel in person to the experimental infrastructure.

In sum, genuine virtual research organisations are not yet widespread, but there are a number of examples already which come close to it.

3.3.11 Synopsis: how "cyber" is academia today?

Based on the criteria of "cyberness" (cf. 1.2.3) discussed in the previous sections and the empirical evidence gathered for this study, we are now in a position to conclude on the status quo. Overview 3-1 below is a synopsis of the overall conclusions of sections 3.3.1 to 3.3.10. On the one hand, it shows that in only two of my ten dimensions, my selection of fields do not show some degree of "cyberness" at all. The assessment of one dimension ("hyper/multimedia") has to be split, as "multimedia" is more widespread. Groupware, E-conferencing and genuine hypertext are the only aspects of "cyberness" with a still very limited range of dispersion.

"Cyberness" criterion	Summary
E-mail:	Used widely in most fields
E-journals:	Growing numbers in many fields, prestige still rather low
Hyper/multimedia:	Hypertext almost unknown, multimedia more widespread
E-conferencing:	Only rare examples
E-lists:	Widespread, but more informational than discussion
E-archives:	Exist wherever there is an important pre-print culture
Disciplinary databases:	Standard tool in most fields and ever growing importance
Digital libraries:	More advanced in journal-based fields than in book-oriented ones
Groupware:	Almost unknown
Virtual institutes:	Not yet widespread but some examples

Overview 3-1: Status quo of "cyberness"

On the other hand, we see that in three dimensions (namely E-mail, E-lists and disciplinary databases) my academic disciplines are very "cyber". By contrast, with regard to E-journals, multimedia, E-archives, digital libraries and virtual institutes, the result is not uniform. Why this is so, and whether it will change, will be discussed below (3.4).

It is tempting to generate a single overall measurement for "cyberness" for each sub-discipline. The problem is, however, that such an aggregation seems to hide more than it would reveal. Additionally, the measurements of the various criteria are all of a qualitative nature, and it was necessary to use different scales.[454] Even re-analysing my evidence would not help as I do not have enough information to standardise the scales. What I can do, is to turn my qualitative data into semi-quantitative fuzzy scales, i.e. figures between Zero and One.[455] See Table A-2 in Annex I for the whole set. The question remains, however, how to weight the criteria. Would a "score" in, say, the dimension "virtual institutes" be of equal importance as in "pure E-journals"? For lack of any convincing weights, I chose to meet this challenge by not computing one single, but two different scores for

[454] For instance "not important"–"not too important"–"important"–"very important" (for the status of E-lists) as opposed to "(not existent)"–"low"–"low, but growing"–"medium"–"high" for the prestige of E-journals or "none"–"some"–"many" for the spread of disciplinary databases. That is, the scales have varying numbers of sub-divisions (in the above examples four, five, and three). Furthermore, I also used exact figures and rankings with a view to E-journals, parallel journals and E-lists.

[455] See Ragin (2000, 153ff.) on fuzzy variables in qualitative social science analysis.

"cyberness". One is the average of the scores related to "*cyber-publishing*" in the wider sense, i.e. a combination of the five variables "E-journals (number)", "E-journals (prestige)", "E-prints", "hyper/multimedia" and "digital library". The other is computed from six variables, namely "groupware", "E-lists (importance)"[456], "virtual institutes", "disciplinary databases", "E-mail" and "E-conferencing", and is called "*cyber-co-operation*".[457] The computed values for these two dimensions are listed in Table A-3 in Annex I.

The area spread between the x- and y-axes in Figure 3-5 is a representation of this two-dimensional property called "cyberness". The closer a sub-discipline is marked in the upper right-hand corner of this area, the more "cyber" it is. Vice versa, the closer it is in the lower left-hand corner, the less "cyber" it is.

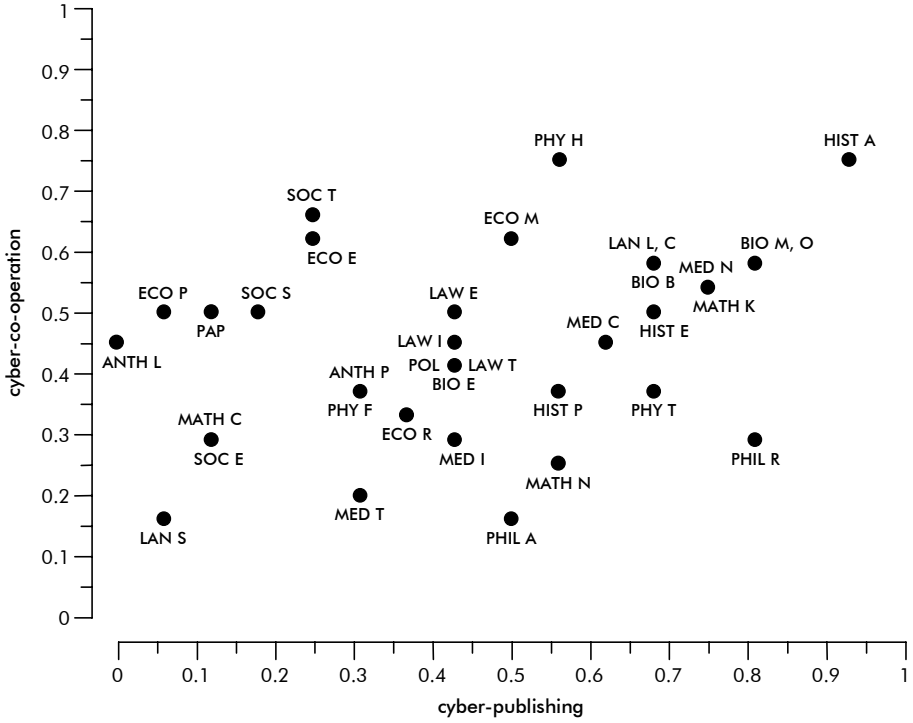


Figure 3-5: Measuring "cyberness" in two dimensions for sub-disciplines

[456] Note that it was not possible to compute exact numbers of E-lists for each of my sub-disciplines on the basis of the DSEJ. I therefore had to take the available data from the interviews. As I did not ask for numbers, but for importance only, it is not possible to include the number of E-lists in each field in this aggregated cyber-co-operation measure. By contrast, I did ask for an estimate of E-journals in each sub-discipline and can therefore include these figures here (exact figures from the DSEJ are again not available).

[457] This two-fold aggregated measurement of "cyberness" also helps to alleviate, but cannot completely solve another problem of aggregation. "Less cyberness" in a dimension where ICT use does not make sense in *this* sub-discipline would distort the overall result without adding valuable information. For instance, if co-operation is not an issue in one field, no groupware use comes as no surprise. To avoid such artefacts I would have to construct a relative score of "cyberness" – relative to the reasonable potential of ICT in this field. This is, however, a very tricky business with many questionable premises and difficult assessments.

Given the various problems and uncertainties of the two aggregated cyber-measurements as discussed above, we should take the above figure not as an exact representation of the reality, but rather as a "soft", indicative picture. However, from the point of view of the interviewer who has discussed these issues with fifty people and, in addition, surfed a lot in the academic WWW, the computed picture comes quite close to preliminary expectations.

A sensitive interpretation of Figure 3-5 reveals the following noteworthy aspects. Among the sub-disciplines studied here, North-American history seems by far the most "cyber" as it rates highest in both dimensions. In the "more cyber" cluster, we find some sub-disciplines of a wide range of disciplines, including biology, medicine, physics, language studies, mathematics and economics. Slavic studies, by contrast, seem the least "cyber". Other "less cyber" specialities are Latin-American studies (anthropology), constructivistic mathematics, empirical social research and thorax anaesthesia (medicine).

Going one step of aggregation further, I compute the two measurements for "cyberness" at the level of whole disciplines (see again Table A-3 in Annex I) and arrive at Figure 3-6:

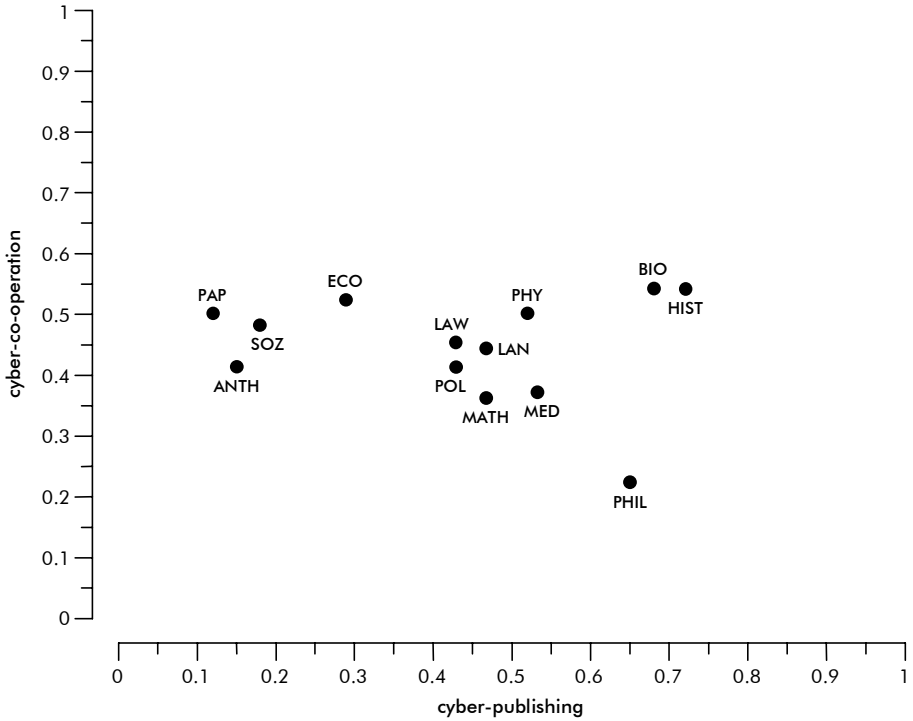


Figure 3-6: Measuring "cyberness" in two dimensions for disciplines

Again, a big caveat should be kept in mind when interpreting this figure because the problems of aggregation mentioned above certainly exist here again. However, the picture gives a rough indication of where the various disciplines are located in this "cyberness space" at the moment. Note that the considerable variations within the disciplines lead to a "denser cloud", that is the data points are not spread throughout the whole area.

3.4 Explaining the differences: a few hypotheses under scrutiny

Both the cross-(sub-)disciplinary comparisons in section 3.3 and the case studies in section 3.2 revealed that ICT is used quite differently in the various academic fields. Given that the CMC technology is by and large the same for each discipline, we need to search in the extra-technological realm for explanations of this variation among the disciplines. For instance, the empirical evidence collected by Walsh/Bayma (1996, 358) suggests that the effects of CMC on scientific work "are heavily mediated by the social contexts into which the technology is introduced". Also Leskien (1996, 110f.) points at the need for differentiation and at the grade of topicality, the size and type of information and the preferred medium which differ from speciality to speciality, from group to group and from purpose to purpose. A systematic analysis of the ICT-related differences, however, has not yet been undertaken. In the following, I shall discuss in turn a number of hypotheses taken from the social contexts, which may explain the differences. These have already been outlined in section 1.2.3 of the chapter on the conceptual framework of this study. I will base my answers both on the empirical material described in the two previous sections and on additional data on some key characteristics of the various disciplines which has also been generated by my expert interviews. In addition, I will look into the general STS literature focussing on differences among disciplines.[458]

Following my "change model" (cf. 1.2.3), I shall now analyse in more detail at the subset of disciplinary factors influencing how ICT impacts on scholarly communication.[459]

(SUB-)DISCIPLINARY FACTORS influencing academic communicative patterns

(1) *General co-ordinates*
Size and distribution around the globe

(2) *Functional aspects:*
"Embeddedness" in physical locales;
visual orientation;
dependency on data;
pace of discovery and time pressure;
geographic focus of subject

(3) *Economic factors:*
Closeness to economic application;
competitiveness; funding

(4) *Cultural parameters:*
Science family; publishing traditions;
uniform method/style;
cumulative production;
culture of collaboration

(5) *Agency:*
existence of cyber-entrepreneurs;
reputation of editing institution

Overview 3-2: Summary of (sub-)disciplinary factors in the "change model"

[458] For instance, my analysis is informed by the studies of Kolb (1981) on learning styles in the various disciplines and by Becher (1989) who compared a number of disciplines in-depth using the image of "tribes" and "territories" as well as "rural" and "urban" modes of scholarly research.

[459] Overview 3-2 represents a subset of factors listed in Overview 1-6, Overview 1-7 and Overview 1-8 of the sub-sections of 1.2.3.

3.4.1 General co-ordinates of disciplines

Under this heading, both the size of the community and their distribution around the globe are under scrutiny.

3.4.1.1 Size of the scientific community

The overall number of active researchers in a speciality and their distribution around the globe could be of importance. The smaller and more specialised a community of researchers is, the more important it could be to have the opportunity to keep contact and to collaborate via ICT. In this sense, Noam (1995, 248) argues that "least affected will be fields that do not experience substantial growth and specialization, and where researchers share a strong core. (...) Most affected will be highly specialized research, where keeping up to the minute is critical."

As already indicated above[439], there are no exact figures available as regards the size of sub-disciplines. Such statistics either do not exist or they are computed on a national level, but with no comparable groupings. Often they only include employees at universities, but not the extra-university sector. The best proxy for size of disciplines available seems to be the number of authors in the databases of the Institute of Scientific Information (ISI). The figures are, however, not too trustworthy as there is both a bias towards US-based research and towards the natural sciences. Other proxies are the number of doctoral students in the US in 1999, as well as the total number of journals included in the ISI database (but they are at least as biased). The expert interviewees had considerable trouble estimating the size of their scientific communities. Most answers were rather vague. Nonetheless, they helped me in my attempt to compare the sizes of the disciplines. See Table A-4 for the figures and indications used.

If we compare the relative sizes of disciplines with the ranking of the disciplines based on the measurement for "cyber-co-operation" (as computed above in 3.3.11), we arrive at Figure 3-7.

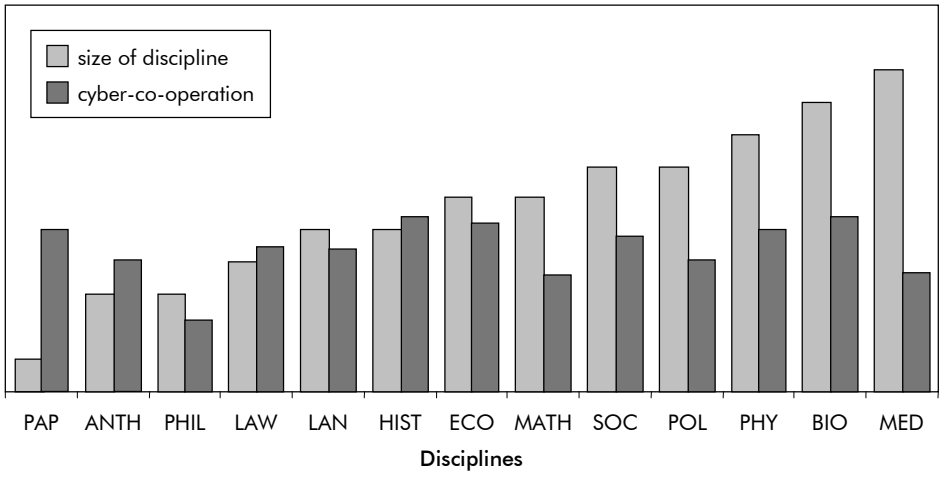


Figure 3-7: Comparing "cyber-co-operation" with "size of discipline"

Obviously, at this level of aggregation, there is no overall (negative) correlation between being more "cyber-co-operative" and "size". It is nevertheless telling that the tiny discipline of papyrology has a level of "cyber-co-operation" comparable to other much larger disciplines.

Unfortunately, it was not possible to gather more precise data on the sizes of the sub-disciplines, not even in the expert interviews. Therefore, we cannot have a look at a less aggregated level as regards size. In the interviews, I also asked for "size dynamics", that is whether the experts felt that their field was growing or decreasing (Table 3-11).

Table 3-11: Size dynamics of sub-disciplines

SOC[E] ECO[M]	BIO[O] HIST[A, P] PAP	MED[N, I, T] LAN[S] PHIL[R, A] ANTH[P] LAW[T] PHY[F, S] MATH[C, K]	HIST[E] ECO[E] MATH[N]	BIO[M, B, E] .. POL SOC[S, T] ECO[P, R] PHY[H] LAN[L, C] MED[C] ANTH[L] LAW[I, E]
decreasing	*rather/slightly decreasing*	*stable*	*rather/slightly growing*	*growing*

However, not all of the shrinking fields are those with higher scores in "cyber-co-operation" (both SOC[E] and HIST[P] are less "cyber" when it comes to co-operation). By contrast, we find that most growing fields have rather high scores in "cyber-co-operation" (the exceptions being MATH[N] and ECO[R]). All in all, "size dynamics" does add equally little to our understanding of the differences between sub-disciplines.

A further hypothesis suggested in the literature is that formal communication via publications may be affected by size because the number of potential readers directly affects pricing and hence the likelihood to shift online. The smaller the community, the smaller the number of copies of the relevant journals, the higher the price per copy, the greater the attractiveness to save money by shifting to online publication. There are indeed examples of such shifts in small research communities, such as literature studies[460], with a view to saving money. I shall discuss this issue in the section on the economics of E-publishing (9.1.1).

With regard to E-pre-print archives, a similar argument has been put forward by Ginsparg (1996). He hypothesises that the likelihood for acceptance and utility of free electronic dissemination of not reviewed material may depend on the proportion of authors vis-à-vis the readers in a field. In physics, where "the author and reader communities (and consequently as well the referee community) essentially coincide", i.e. in a "closed peer community" the situation might be different from "research communities comprised of a relatively small number of authors and a much larger number of readers". A good example of the latter type is law. Here the community of readers also comprises the legal professions (lawyers, judges, administrators) who are, in most cases, only consumers of the literature. And indeed, there are no E-pre-print servers in law (and E-publishing is still in its infancy). In medicine where there is a very, very large community of practitioners, too, we do not find E-pre-prints and E-servers either. By contrast, the community of papyrologists is certainly a case where readers and authors largely coincide. None-

[460] Cf. the Bryn Mawr Reviews (<Cyberlink=405>).

theless, there are no E-pre-prints. Furthermore, papers by economics researchers do have a larger public, but there is an important E-pre-print system in place. Therefore, Ginsparg's hypothesis has to be rejected in this mono-causal form.

To sum up, on the basis of my data, I cannot confirm the hypothesis that ICT use is related to the size of the research community. It seems rather that "cyberness" comes with both large and tiny communities.

3.4.1.2 Distribution of the relevant community around the globe

The more dispersed the researchers of the same field are, the more likely the use of ICT seems in order to keep in contact and to collaborate. As Hert notes, "particle physics is a geographically dispersed but also tightly coupled scientific community. Computer-mediated communication is therefore more frequently used than in more autonomous groups, such as experimental biologists." (1997, 331) Walsh/Roselle (1999, 68) point at mathematics, physics and aerospace engineering as examples. Walsh/Maloney (2002) found that computer network use is associated with more geographically dispersed collaborations. Finholt/Olsen (1997, 33f.) report on the prospective collaboratories in psychology. Collaboratories may be a solution where in cross-cultural/comparative research the dispersion of researchers complicates communication and when activity must be co-ordinated across time zones (Finholt/Olson 1997, 33). Take the example of landlocked physical oceanographers overcoming some of the liabilities of their location by maintaining contact with scientists at elite coastal research centres (Hesse et al. 1994, quoted by Finholt/Olson 1997, 34). The latter expect to see collaboratories in neuroscience and in cross-cultural research where the geographic dispersion complicates communication. The latter example is confirmed by this study, as transdisciplinary cultural studies (LAN^{C}) indeed scores high in "cyber-co-operation" (cf. 3.2.1.1).

Most experts answered with regard to the degree of distribution of their community around the globe that their field was rather dispersed:

Table 3-12: Distribution of communities

BIO^{B} PHY$^{H, F}$ MED^{T}	BIO^{E} PAP PHIL^{R}	ANTH^{P} LAW^{I}	BIO$^{M, O}$ HIST$^{E, A, P}$ ECO$^{P, E, M, R}$ PHY^{S} MATH$^{C, K, N}$ MED$^{C, N, I}$ LAN$^{S, L, C}$ PHIL^{A} ANTH^{L} LAW^{E} POL SOC$^{E, S, T}$
packed	*rather packed*	*rather dispersed*	*dispersed*

Let me first look at the cases that are less dispersed. In contrast to my initial hypothesis, three of them, while "packed" fields, nevertheless score high in the "cyber-co-operation" dimension (see Figure 3-5 above). All three are, however, special cases: As already noted by Hert above, the home bases of high-energy physicists (PHY^{H}) are distributed around the world, but the experiments are carried out at a few central places (like CERN). They are packed together, only when they work at these central facilities. When they are not in one place (around two thirds of their time), they stay in contact through the Internet. The biotech researchers (BIO^{B}) collaborate through common disciplinary databases only, but they are "weak" in the other dimensions of "cyber-co-operation". This is probably due to the high degree of competition in the field, which leads to more co-opera-

tion inside the research groups, but to fewer outside contacts. Papyrologists are special inasmuch as they are a very small group. Their smallness automatically leads to their concentration in a few places (in particular, where there are archives of papyri).

While it seems possible to find good arguments with a view to discarding these three "deviant" cases (PHY^H, BIO^B, PAP), I am nevertheless unable to confirm the hypothesis that more dispersed communities use more ICT. The reason is that I find a number of sub-disciplines in the group "dispersed" in Table 3-12 which rank low in terms of "cyberness" (e.g. Slavic studies, empirical social research, constructivist mathematics or analytical philosophy). By contrast, my evidence leads me towards the conclusion that ICT use is not related to the spreading of the respective research communities. This is, however, not to say that more dispersed communities do not profit even more from ICT. For instance, oceanographers with remote laboratories seem to be a case in kind. Furthermore, E-tools may as well be heavily used in local settings, too (E-mails to colleagues next door are widespread).

3.4.2 Functional explanations

The degree of ICT use in a (sub-)discipline may be connected with the way content is produced in a field. Various parameters are functional for the research, such as the researchers' need of physical locales, their visual orientation or dependency on numeric data, their time constraints or the geographical focus of the subject.

3.4.2.1 "Embeddedness" in physical locales

Among the natural scientists, Merz (1998, 315) compares theorists and experimentalists: "While the workbench of a biologist provides a unique setting (and biologists have to travel in order to visit the singular bench arrangements of a colleague), [particle physics] theorists can 'reproduce' their place of work at each location that provides computer access. In contrast to experimental physicists who are tied to apparatus embedded in a physical locale, theoretical physicists are much less constrained to work in one particular setting." Merz adds that, furthermore, "theoretical objects, such as physical quantities, models, theories and techniques, are symbolic entities without 'roots' or anchorage in physical space." From this, I derive the hypothesis that the more embedded research is in a physical locale, in other words: the more tied to a special physical setting it is, the less likely distant co-operation (via electronic means) is.

From among my sub-disciplines, it is high-energy physics and fluorescence analysis plus all biology and medicine sub-disciplines, as well as anthropology which rely on physical locales. All others are more or less independent from being present at a certain physical place. If we compare these two groups, we see that there is no significant difference as regards their level of "cyberness". The extreme case is high-energy physics with a high score in cyber-co-operation although they rely on their (central) experimental apparatus and travel a lot. Obviously, there are two distinct and regularly exchanging phases in the work of high-energy physicists: those in the centre and those back in the home offices. In the latter phase, co-operation started in the centre is kept alive through E-mail etc. Interestingly, also the biology sub-disciplines all rate relatively high in the co-operation dimension. The reason is simple: co-operation does not only take the form of E-mail exchange between distant researchers, but today, joint databases play an important role.

Also the work of Merz shows that even those not tied to specific spaces would not automatically use ICT more. For instance, "(t)heoretical physicists seem to be among the most passionate travellers in science" (Merz 1998, 319). They have favourite meeting spaces like research centres and institutes (and to some extent conferences) which Merz calls "embedded locale" (ibid., 321).

We may conclude that "embeddedness" alone is not enough to explain the variations.

3.4.2.2 Visual orientation

Sub-disciplines vary as to their visual or non-visual orientation. In those fields where multimedia communication offers substantial improvements, the likelihood of their implementation should be higher: "In visually oriented fields, digital communication offers substantial benefits, as video and sound may be embedded in digital documents." (Getz 1997, 3) One of the paradigmatic disciplines in this respect is astronomy:

> "Images constitute an important part of research data in astronomy. The Astronomy Digital Image Library aims to support astronomers' productivity by providing easy access to data via the Web. Its collection of fully processed images permits researchers planning new projects to access previous observations as an aid to sensitivity calculations or exploring new questions. New data may also be compared with previous observations to allow a multi-frequency study of particular objects. Astronomers may also use the library to archive their final processed images and related data and share them with collaborators and colleagues without having to use their own disk space or as a way to present results in a manner that complements the presentation in printed journals." (OECD 1998, 200)

In my sample of sub-disciplines, we have quite a number that are visually oriented:

Table 3-13: Visual orientation of sub-disciplines

LAW[I, E, T] SOC[E] BIO[B] ECO[E, M, R] PHIL[R, A] POL LAN[S] MATH[C, K, N] MED[T]	HIST[E, A]	SOC[S, T] ECO[P] LAN[L, C] ANTH[P]	**PHY[H, F, S]** **BIO[M, O, E] HIST[P]** **PAP MED[C, N, I] ANTH[L]**
no	*changing*	*partly*	*yes*

Table 3-4 (copy): Spread of hyper/multimedia

LAW[I, E, T] MED[T] LAN[S, C] **ANTH[L]** **PAP** POL SOC[T] BIO[E] **PHY[F]** ECO[P, E] MATH[C, K]	SOC[E, S] ECO[R] PHIL[A] ANTH[P]	**BIO[M]** ECO[M] **PHY[H, S]** MATH[N] **MED[C, N, I]** LAN[L] PHIL[R]	**BIO[B, O]** **HIST[E, A, P]**
none	*isolated examples*	*some*	*relatively many*

Legend for both tables: **BOLD** *sub-disciplines are marked in both tables*

Do those more visually oriented use multimedia more often than others? If I compare the two tables above (the second is identical to the one in 3.3.3), I find some hints in this direction. For instance, pre-history (HIST^{P}) as well as molecular oncology (BIO^{O}) are both visually-oriented and use multimedia. The other historical sub-disciplines are changing in their perception of "visuality". Also some of those fields where I could detect at least some examples of multimedia are to be found in the group of visually or partly visually oriented fields, for instance molecular micro biology (BIO^{M}) and applied linguistics

(LAN[L]). Medicine underpins the initial hypothesis: Whereas one of the sub-disciplines (thorax anaesthesia – MED[T]) is neither visually oriented, nor do we find any examples of multimedia, the contrary is the case for all other medical sub-disciplines.

There are, however, a number of cases that need a special explanation, as they seem to contradict my hypothesis. Why is it that we find papyrology on both ends of the above tables? Papyrologist have large online databases with pictures of their papyri but, so far, they have no E-publications, hence no instances of multimedia publications. The potential, however, is great, as the expert interviewees have noted. The same seems to be the case in anthropology. Anthropologists use pictures and film (and audio-tapes) in their daily work. Nonetheless, multimedia is still non-existent or there are only isolated examples in this field. In fluorescence analysis (PHY[F]) multimedia elements have so far only been used in relation to teaching although graphics do play a role in publications. Again, there is a potential that is not yet fully explored.[461]

Sub-discipline specific *technical* limitations may be part of an explanation, too, in particular the so-called rendering or representation problem. It may be difficult to transmit or represent the non-textual information common in a field. According to Hailman (1996, summarised by Walsh/Roselle 1999, 68; see also OECD 1998, 199), ornithology is an example where graphical representations are important. One of the interviewees mentioned the rendering of mathematical symbols in E-mails and in the WWW. There is an initiative to incorporate MathML in HTML, but this will still take some time. For now, this difficulty certainly explains why mathematicians have only limited "discussions" over E-mail, but rather send attachments with postscript of TeX files back and forth. Also in the humanities (e.g. archaeology or history), there are (or have been) problems with representing the artefacts in digital form without losing the tiny details necessary for research. There are, however, already a few technical solutions available for this problem.[462] In this context, Leskien (1996, 115) argues that it might be easier for an archaeologist to work with a number of books flipped open than to switch between various "windows" on a computer screen. Perhaps this problem could be solved by better screen technology: by larger screens and by software that may allow half-transparent windows, which could be overlaid to ease comparisons. Furthermore, this is also a question of availability. Even if the researcher resides in an institution with a large collection of primary sources, it is impossible that the collection will include every piece for comparison. In general, collections are reluctant to borrow originals. Hence, the researcher will be better off with zoomable, fine-grained digital copies than with no copies at all or with simple photographs.

To sum up, the more importance pictures have in a sub-discipline, in other words the more visually oriented it is, the greater the likelihood finding multimedia applications there. However, there are counter-examples of fields that acknowledge the potential, but still have not discovered it or which have to overcome technical limitations first. Note that my conclusion in 3.3.3 was that multimedia is not widespread at all. Hence we may be confronted with an early phase of the development here – which makes it difficult to draw too far-reaching conclusions.

[461] Note that other prima facie contradictions between the two tables are due to the nature of Table 3-4 which combines both hypertext and multimedia. For instance, philosophy is a text and not visually oriented discipline, but I found examples of hypertext (but not multimedia). Also number theory (MATH[N]) is such a case.

[462] See for instance the Blake Archive (<Cyberlink=395>) or the CEEC archive (<Cyberlink=566>).

3.4.2.3 Data and model driven fields

Academic fields vary as to their dependency on data. The more dependent a discipline is on large quantities of data and on modelling, the more dependent it is on computer applications and hence the greater the likelihood of an open-mindedness towards extensive use of computers and ICT. In the context of the discussion of collaboratories, a committee of the Computer Science and Telecommunications Board (US) argues that "any science that makes extensive use of computing for modelling, simulation, data analysis, and data storage and retrieval can benefit from the use of collaboratories" (CSTB 1993, 2). "For disciplines that are data-driven, databases, libraries, and access to such [cyber]resources are central requirements. (...) For disciplines that are more model-driven, algorithms and software are also key resources." (ibid., 6) For instance, oceanographers, earth scientists, atmospheric scientists produce large amounts of data to be shared (NRENAISSANCE Committee et al. 1994, 117). They often rely on collaboration and were among the very first to explore the possibilities of a collaboratory, called SCIENCEnet (Finholt 2001, 11).[463] In this respect, the OECD report argues that "(t)he situation differs substantially among disciplines, however, for both numeric and bibliographic databases. For materials engineering, ICT-based distribution of information seems to be generally lagging, with numeric databases on materials available only in-house, notably in universities and in companies. There is insufficient demand for broader distribution of the data." (OECD 1998, 202)

The following table shows the answers of my experts regarding the importance of data in their fields. With a view to substantiating the hypothesis that more data-dependency leads to more "cyberness", I shall first compare it to Table 3-8 on disciplinary databases.

Table 3-14: Dependency on (numeric) data in sub-disciplines

HIST^{E} MATH^{K} PAP LAN^{S} PHIL$^{R, A}$ LAW$^{I, E, T}$	POL BIO^{E} HIST^{A} PHY^{F} LAN$^{L, C}$ ANTH$^{L, P}$	HIST^{P} PHY$^{H, S}$ MATH$^{C, N}$ **MED**$^{C, N, I, T}$ SOC$^{E, S, T}$ BIO$^{M, B, O}$ ECO$^{P, E, M, R}$
no	*partly*	*yes*

Table 3-8 (copy): Spread of disciplinary databases

MED$^{C, T}$ PHIL^{R}	SOC$^{E, T}$ HIST^{P} ECO^{R} PHY^{F} MATH$^{C, K, N}$ MED^{I} LAN$^{S, C}$ ANTH^{P} PHIL^{A}	SOC^{S} BIO$^{M, B, O, E}$ HIST$^{E, A}$ POL ECO$^{P, E, M}$ PHY$^{H, S}$ PAP MED^{N} LAN^{L} ANTH^{L} LAW$^{I, E, T}$
none	*some*	*many*

Legend for both tables: Sub-disciplines in **BOLD** *and* UNDERLINED *are marked in both tables*

The comparison does only partially support the initial hypothesis. On the one hand, most sub-disciplines that work with numerical data at least partly have at the same time at least some online databases. There are, however, two counter-examples from medicine

[463] There are further collaboratories to be listed under this heading: the Upper Atmospheric Research Collaboratory (UARC) and its successor, the Space Physics and Aeronomy Research Collaboratory (SPARC) (Finholt 2001, 14 and 24) and the Environmental Molecular Sciences Collaboratory (ibid., 16).

(MED[C, T]). The experts argued in these two cases that the data generated are considered secret or too touchy to be published in databases. On the other hand, a number of fields where data do not play a role, do nevertheless have such databases. This shows that "data-dependency" is no necessary cause for databases as there may be other types of databases, e.g. collecting pictures (HIST, PAP) or texts (HIST, LAW).

Second, when it comes to "modelling" as a characteristic of a field's methodology, we have economics sub-disciplines which work with models and have many disciplinary databases, too (in particular ECO[E]). In this sense, a relationship is likely. The introductory quotes regarding atmospheric studies and similar fields support this conclusion.

Third, those sub-disciplines which have virtual institutes or collaboratories (at least in statu nascendi; cf. Table 3-10) are also listed among those which are at least partly data-oriented. The only exception is the text-oriented sub-discipline IT law with slight beginnings of virtualisation.[464]

In sum, data-dependency or being model-driven is likely to favour ICT use, in particular in the form of disciplinary databases or virtual institutes.

3.4.2.4 Time pressure – rhythms – pace of discovery

In disciplines with higher time constraints, faster media may be more welcome. In other fields, a relatively slow pace of discovery may limit benefits. Speed of circulation is not as important in the humanities or most of the social sciences, "where knowledge has a much longer half-life than in the sciences because the passage of time alone almost never renders this knowledge superfluous" (Tomlins 1998). Walsh/Roselle hypothesised that ICT may play a minor role where old literature is still relevant and publication lags are not considered problematically long (Walsh/Roselle 1999, 68). In "disciplines where the book has been the dominant form of publication" (Mueller 2000b, 2), i.e. where the scholars "ponder a few things deeply", or in "pedagogical environments where you teach subjects well contained within the covers of a book", it seems no big advantage to get at the material to be read quickly. By contrast, "where scholarship depends on the assembly of information from disparate sources, a digitised environment can significantly lower the 'look-up' cost as well as the cost of extracting information from the source" (ibid., 3). And the OECD concluded that „(i)n fields such as ornithology (...) a relatively slow pace of discovery may limit benefits" (1998, 199). Comparing the scientific system with, e.g., capital markets which profit from CMC considerably, Stichweh notes that science reacts rather in a retarding than accelerating manner. He assumes that the reason for this difference is the different degree to which new information can be absorbed. Therefore information overload in science could be even enhanced by the new technologies.[465] Therefore Stichweh asks for an in-depth analysis of time rhythms and theory structures in the various disciplines (where he suspects important differences) with a view to be able

[464] In 1993, the CSTB reported evidence from molecular biology, oceanography and space physics which are three fields that varied greatly in their use of ICT and in the applicability of the collaboratory concept. "Despite these variations, all three fields share a common dependence on the collection and analysis of large amounts of data." It was furthermore found that "collaboration is becoming more common (albeit at different rates) in these fields, within and between disciplines; that the conditions under which individual scientists work vary substantially; and that the familiarity with, access to, and use of computer-based technology vary significantly across fields." (CSTB 1993, 2)

[465] See however Harnad (1990, 3) with his convincing counter-argument that it is "in fact easier to filter electronic mail than it is to filter real mail and phone calls".

to assess the need for and the chances of implementation of the new technologies (1989, 60ff., transl. MN).

I am not in a position to fulfil Stichweh's research programme in this study, but I am nevertheless able to draw some conclusions on the basis of my empirical data. The following two tables show the answers of my expert interviewees concerning time-pressure and pace of discovery in their fields.

Table 3-15: Time-pressure in sub-disciplines

PHY[S] LAN[S] MATH[C, N] ANTH[L]	HIST[E] ECO[M, R] PHIL[A] MATH[K] PAP	HIST[A] LAW[E, T] SOC[E, S, T] ANTH[P] PHIL[R] POL LAN[L] PHY[F] PHY[H] ECO[E]	PHY[H] HIST[P] LAN[C]	BIO[M, B, O, E] ECO[P] MED[C, N, I, T] LAW[I]
no	*rather no*	*partly*	*rather yes*	*yes*

Table 3-16: Pace of discovery in sub-disciplines

ANTH[L] ECO[M] PHIL[R, A] MATH[C, K] LAN[S, C] SOC[E, T] HIST[E, A, P] PAP PHY[H] MED[T]	SOC[S] ECO[P, R] PHY[F]	POL ANTH[P]	ECO[E] MATH[N] LAN[L]	BIO[M, B, O, E] PHY[S] MED[C, N, I] LAW[I, E, T]
slow	*rather slow or accelerating*	*medium or partly slow, partly fast*	*rather fast*	*fast*

Comparing these two tables, one discovers that there is no exact match between time-pressure and pace of discovery. For sure, the life sciences are in both cases at the top end, but many other fields rank differently in the two dimensions (in total, only one third of all sub-disciplines do not "change places" in the two tables). This hints at other sources of time-pressure than the fast pace of discovery. For instance, in many fields, research is increasingly organised in projects with deadlines. Also, for those without a tenured position, competition with their peers for such positions increases time pressure as one is forced to publish faster and more than the competitors. But even where the general pace of discovery is rather low, being first with an answer to a long-standing puzzle of the discipline or posing a question for the first time or framing something in new terms may be important for a researcher's prestige and hence an accelerating factor.

Other factors outside the realm of pure research which lead to relatively more time pressure can be found in the "real world". Pre-history (archaeology, HIST[P]) is a case in point. There is prevalently great time-pressure due to the fact that excavations are mostly done on building sites where construction is discontinued for a couple of months only. The archaeologists have to work fast in order to seize the material in that time-slot before construction will destroy all remaining traces of the past. At the same time, this constant pressure to excavate (there are constantly many, many construction sites being opened and often you may find something archaeologically interesting) leads to less time for interpretation and analysis, hence to a slower pace of discovery.

In other disciplines, what is considered progress or discovery whose pace could be rated, is not so clear, in particular in some of the humanities or social sciences sub-disciplines. For instance, those researchers looking at so-called "moving targets", i.e. at (mainly) so-

cial institutions which are under constant and dynamic development, often have a hard time following the directions and current characteristics of their research object. The results of this type of research are necessary and worth the effort, but are often soon outdated when "the course of history bypasses research". Take, for instance, legal scholars who try hard to keep up-to-date with the analysis of the current legislation that may soon be replaced by a new law or judgement. If you measure progress in terms of scholarly output, i.e. analyses of legislation, then it is a fast discipline (progress may, however, be doubtful). Another example would be the study of policies, which by their very nature are constantly evolving. Also here, time pressure can be acute, but progress in theoretical terms rather slow.

From all this we have to conclude that time-related aspects cannot play a very important role in an overall explanation of disciplinary differences. However, my next analytical step reveals that, on a general level, time has explanatory power nonetheless.

Let me compare the scores in the two dimensions above (pressure and pace) with the spread of E-publishing. E-journals are a fast medium compared to P-journals. Indeed, most disciplines, which rank high in time-pressure and pace of discovery, are those on the top end of the E-journal ranking (cf. Figure 3-1). There are only two exceptions: economics and law, which do not have many E-journals. As to economics, there is no real contradiction as economists communicate a lot via working papers. Hence E-pre-prints fulfil economists' needs for speedy communication. As to law, the explanation lies with the fact that the traditional law journal system seems capable of providing fast publication already. There is not much reviewing involved in legal journals and most journals have few space limitations so that they are able to publish even long manuscript within a very short time (often less than three months).

Also whether or not pre-prints or, nowadays, E-pre-prints[466] are used to communicate new research results may be related to time. Kircz (2001, 6) argues in the context of quality control that "the issue is very much domain dependent. Whilst in theoretical physics the pace of research is such that every new idea is immediately broadcast via pre-print servers, although often after internally peer reviewed by the researcher's institute, in more experimental fields, the tempo is more relaxed. After all, it is easier to steal an idea than to redo an experiment." This is not in conformity with my data: the theoretical physicists in my sample (PHY^S) seem to be under less time pressure than the (experimentalist) high-energy physicists (PHY^H). The latter have a fast E-pre-print system whereas the former do not. Fluorescence analysis (PHY^F), an experimental field, is somewhere in the middle as regards time pressure and has no pre-print system. By contrast, economics with an important E-pre-print system confirms Kircz' hypothesis, as it is a rather fast discipline, which relies more on ideas than experiments. Stichweh's observation may help understand the situation: "On the one hand, there seems to be less need for CMC in the theoretical discourse upon the integration of empirical evidence since, in general, the pace of development in this area does not call for it. On the other hand, there is a high demand for synchronous provision of all relevant data due to the very non-simultaneity of theory and empirics – a demand which cannot be satisfied by asynchronous and decentral publication of experimental data." (1989, 62, transl. MN) Furthermore, as we have seen in Table 3-16, some disciplines have a very long time horizon for their projects due to the considerable and very specific infrastructure needed.

[466] Remember that all sub-disciplines where working papers or pre-prints play an important role have in fact moved to electronic distribution of the papers (cf. 3.3.6 above).

The OECD report (1998, 213) argues that this influences their assessment of non-reviewed papers. Since they have been written collaboratively over a long period, they have undergone intensive review by the time they appear in an E-pre-print archive.

With a view to explain why other sub-disciplines with high time pressure (such as the life sciences) do not have an E-pre-print system, Kircz holds that in "medicine, the question [of lacking quality control in pre-print series] is intrinsically more sensitive as new medical information is often rocketed to high levels of public fantasy. In this field, the discussion on ethics and misconduct is a permanent concern." (ibid.) While this may be true, a more important reason for no pre-print system in the life sciences seems to be their proximity to economic applications (see below 3.4.3.1).

To sum up, there is no easy answer as regards the influence of time-related aspects, such as time pressure and pace of discovery in a research area, on ICT use. As we have seen, the difficulties start with operationalising both terms. However, my data show at least that the faster a discipline, the more E-journals it produces. Also E-pre-print servers are generally to be found in disciplines with high time pressure.

3.4.2.5 Geographical focus of the subject

The subject of research may serve as yet another starting point for a hypothesis. The more a sub-discipline focuses on national, regional or local subjects and hence relies on national, regional or local resources and publication outlets (in other words, the less internationally oriented) the less attractive it could be as a global medium. For instance, most fields of legal studies, except for public international law, European law and collision law, are oriented towards the national arena. The same may be true for some types of rather locally oriented historical studies. Vice versa, the more international the subject is, i.e. the more questions of international interest are involved, the more global cooperation and exchange might be expected. For instance, cancer research is a worldwide theme, hence cancer researchers all over have constant contacts with each other.
Indeed, the life sciences, physics or mathematics are to be found among the more "cyber" fields. The hypothesis can nonetheless not be sustained in a general form on the basis of my data. To take the two examples above, both law and history rank rather high with regard to E-lists (cf. Figure 3-3). Researchers specialised in North-American history – not a paradigmatic international subject – use E-conferencing regularly (cf. Table 3-5). Also in my overall comparison of "cyberness" (cf. Figure 3-5), the latter discipline comes out as quite advanced, and even tax law (LAW^T) is not to be found at the bottom end. Even the "least cyber" sub-discipline in my sample, Slavic studies, does not support the initial hypothesis as this research spreads over a number of countries.

There are at least two reasons that might explain why this prima facie convincing hypothesis has to be rejected. First, we have to ask whether "locally oriented" research really exists today. When asked whether their sub-discipline is internationally oriented, the interviewees answered almost univocally that yes, it is an international field (different answers were only given by tax and information lawyers). Obviously, they all felt that their own questions are not exclusive to their local community, but that there are others around the world who do similar things. There are international conferences in almost every field today. Note that only one out of fifty interviewees said that he did not attend international conferences whereas all others travelled at least once a year, some much more often. This leads to the conclusion that at the beginning of the 21st century, there is no such thing as genuine local or regional research. In each and every field, there are

reasons to look beyond borders, to compare with similar entities elsewhere, at least to exchange views with fellow colleagues from somewhere else. Second, even if it would exist, this no convincing reason for less ICT use. As I will show elsewhere in this study (cf. 4.3.1.3 on the spatial dimension), ICT is used more and more for local communication, too. With a view to profit from the advantages of asynchronous communication, even colleagues sitting next door exchange messages. There is no reason why a local group of, say, archaeologists specialising on a particular excavation site should not produce a common online database to store their results.

The OECD report mentions as distinguishing characteristics the local character of part of the research in the humanities and social sciences (alongside a generally less collaborative culture, less costly instruments and a less pre-print-oriented culture). The report hypothesises that this will be the reason for other types of impacts of ICT as compared to the sciences. The authors argue that – in contrast to collaboratories and extensive E-pre-print-publishing – "access to data and information and easier communication among researchers may be the main impacts." (OECD 1998, 224) My results show that this is too general a statement, as we have quasi-local sub-disciplines with pre-print culture (e.g. political economy, regional economics) as well as virtual institutes in the humanities (e.g. cultural studies).

In sum, it may well be that those subjects with a "very" international subject have more to gain from ICT or have started to exploit the new opportunities earlier, like most of the natural sciences. However, most fields are increasingly international in focus today, with the consequence that this distinction does not add much to our understanding of the differences among academic fields.

3.4.3 Economic factors

Science and research is not separated from the economy, in particular when it comes to applying research results, but also when it comes to funding research. Economic factors are therefore likely to play a role in the framework of my explanation.

3.4.3.1 Closeness of the (sub-)discipline to economic applications

The more applied the research in a sub-discipline is, i.e. the more likely commercial applications are, the smaller is the openness towards pre-print publications and other forms of sharing information via the Net. In the words of Hert: „(F)ields that are closer to commercial markets, such as chemistry, use this medium less than fields that have no commercial outcomes, such as mathematics." (1997, 331) Finholt explains that in chemistry, most practicing chemists are employed in private firms and that these have "proprietary interests in the products of their employees, specifically intellectual property such as patentable compounds and processes. As a result, chemists as a group use public computer networks less than other scientific disciplines that are dominated by academic practitioners" (2001, 29). Another example is experimental biology "where there is a significant industrial presence and where patent rights may be worth substantial sums" (Walsh/Roselle 1999, 68). In particular cancer and AIDS research are "closely linked to commercial applications, and researchers in these fields often work with the private sector. These researchers are often unwilling to share research methods, materials and results, as the work can be lucrative and is often highly competitive. Publication in biology is centred

around peer-reviewed journals, and pre-prints are quite rare." (OECD 1998, 213) In engineering fields, such as aerospace engineering, Bishop (1994, quoted by Walsh/Roselle 1999, 68) names system security of the networks as particular worries – which is a disguised economic argument, as well.

Table 3-17: Economic applications in sub-disciplines

PAP LAN[S] BIO[E] HIST[E, P]	MATH[K] PHIL[A] POL PHY[S] LAN[C]	HIST[A] PHIL[R] PHY[H] SOC[S, T] ANTH[L, P] LAW[E]	ECO[R] LAN[L]	MED[C, N, I, T] PHY[F] MATH[C, N] SOC[E] ECO[P, E, M] LAW[I, T] BIO[M, B, O]
no	*rather no*	*partly*	*rather yes*	*yes*

Analysing the above results from my expert interviews, I find, on the one hand, some hints supporting the above hypothesis about a negative correlation between possible economic exploitation of the research and E-pre-prints (cf. Table 3-7). In particular, the life sciences are close to economic applications and, indeed, there is neither a pre-print nor an E-pre-print system. The same is true for empirical social research (SOC^E) and constructivistic mathematics ($MATH^C$), fluorescence analysis (PHY^F) and two of the legal fields. On the other hand, I find also evidence for the contrary: Obviously there is a close relationship between economics research and the practical use, but economics is nevertheless a field with a well-established E-pre-print culture. The possibilities to exploit the content of economics research directly are, however, much fewer than for instance in biotechnology. In the latter case, the research is often patentable – something unheard of in the social sciences. To a lesser degree, applied linguistics (LAN^L) is a counter-example to the initial hypothesis as there is a pre-print system. Again, it is not a particularly strong counter-example as the pre-print system is in its infancy. In any case, the hypothesis is certainly not reversible: remoteness from economic applications does not lead to more sharing of early results in the form of pre-prints.

Next we look at the spread of disciplinary databases (cf. Table 3-8), another means of sharing information which should again be negatively correlated with closeness to economic applications. In principle, those fields closer to economic applications have less discipline-wide databases. But again, I find counter-examples.[467] In particular some of the life sciences sub-disciplines share information via databases. What can be done with the shared information and when is, however, regulated. In particular, direct commercial use of data in open databases is, in general, not allowed or has to be negotiated with the originator. Furthermore, researchers often upload their data only after publication in a journal and after filing a patent. Obviously, the biologists constantly evaluate whether disclosing or withholding their results is more beneficial for them (both in terms of career and economic exploitation). Furthermore, there seem to be important differences between the various specialities with some groups being more open to sharing of results and others much more restrictive.

[467] Note that the many disciplinary databases in economics and law are not a case in point here. They play an important role in research, but are not produced by the community of researchers themselves, but by other institutions (cf. 3.3.7).

In sum, although far from providing a universal explanation, closeness to economic applications helps to understand why some sub-disciplines are rather reluctant to share research results through an E-pre-print system.

3.4.3.2 Competitiveness

Partially related to the market-orientation of a speciality (see above 3.4.3.1), a culture of competition might be the key to understanding differences in how ICT is applied: the more external market-oriented pressure is exerted, the more competitive a speciality is likely to be. This relationship is partially underpinned by a comparison between Table 3-17 above (on economic applications) and Table 3-18 below (on competitiveness). You find many of the sub-disciplines at the right-hand end of the tables, i.e. those closer to economic application are in general also competitive fields. There are, however, still other sources for competition: first, competition for jobs if there are not many posts available; second, competition for reputation within one's scientific community. Both are related to each other and at least the former is indirectly also an economic factor.

Table 3-18: Competitiveness of sub-disciplines

MED^{T} LAN^{S} $ANTH^{L}$ SOC^{T} $ECO^{P, R}$ $PHY^{F, S}$	SOC^{S} $HIST^{P}$ PAP LAN^{L} $PHIL^{R}$ LAW^{T}	$HIST^{E, A}$ $MATH^{N}$ POL LAN^{C} $PHIL^{A}$	BIO^{E} $ANTH^{P}$	$BIO^{M, B, O}$ $ECO^{E, M}$ PHY^{H} $MATH^{C}$ SOC^{E} $MED^{C, N, I}$ $LAW^{I, E}$
no	*rather no*	*partly*	*rather yes*	*yes*

The question to explore is whether it is the case that the more competitive a field is, the less likely is co-operation, in particular E-co-operation. If we take the "cyber-co-operation" score (cf. Figure 3-5) as a yardstick, we have to conclude that this is not the case, quite to the contrary: most of the sub-disciplines that are assessed to be competitive by my experts have an above-average score when it comes to "cyber-co-operation". The exceptions are immunpathology (MED^{I}), constructivistic mathematics ($MATH^{C}$) and empirical social research (SOC^{E}) which all do not use groupware and E-lists etc. too much. Note that, as discussed in the previous section, molecular biologists ($BIO^{M, B, O}$) are competitive in a special sense. Competition and collaboration through sharing of information are the two sides of the same goal orientation.

We have to conclude that there is no direct relationship between competitiveness and less ICT use. I shall look into this again below (3.4.4.2) from the point of view of a culture of collaboration in a field.

3.4.3.3 Funding

The average budgetary situation of a speciality and, hence, the availability of state-of-the-art technology (hardware and software as well as access to fee-based databases etc.) may be a factor to explain some of the differences between sub-disciplines. For instance, "(d)isciplines in the humanities have not been well capitalized in part because the need for capital (such as computing equipment and networks) has not been recognized, yet without access to the capital these researchers cannot demonstrate its value in their fields." (NRENAISSANCE Committee et al. 1994, 119; similarly Mueller 2000b and OECD 1988) Also Walsh/Bayma (1996, 359) suspect that changes in funding (and changes in the objects of investigation) contribute to changes in social and work organisation and hence CMC use.

Slavic studies (LAN^{S}) seem to be a case in point. The field is dominated by research units in the eastern part of Europe and by university departments (in the West) which mainly focus on teaching Slavic languages. Both are traditionally the stepchildren when it comes to technological infrastructure. It comes as no surprise that we find this sub-discipline scoring lowest in both dimensions of "cyberness". However, again, this can only be a partial explanation. For instance, thorax anaesthesia (MED^{T}) is certainly not under-financed, but scores nonetheless quite low.

To sum up, the average budgetary situation of a sub-discipline does not play a very important role any more today. With regard to the basic cyber-tools, in particular E-mail (E-lists) and WWW, it seems only a matter of short time that the average funds of all sub-disciplines will be sufficient to let them fully participate.[468] All of these tools are established at all universities (because the more "cyber" disciplines have already demanded them successfully). Therefore, the reasons for some fields to use E-mail etc. less should have to do with other factors. As for less widespread (and dearer) applications like web-cams for E-conferencing or groupware applications, small budgets may still be a reason (however, probably not at the sub-disciplinary, but rather the institutional level).

3.4.4 The disciplinary culture

In the previous sections, we have seen that a variety of both general parameters, functional and economic factors may to some extent influence the way ICT is applied in a field. Now I shall look at the differences of professional cultures. Scientific communications are socially constructed, therefore we are bound to expect differences between the disciplines (e.g. Hert 1997). Shoham (1998, 120), for instance, found in her survey that "informal channels constitute a major source of information" in all faculties. Regarding instructional issues, however, "humanities scholars consult more with colleagues both within and outside their department than do scientists and social scientists". Conferences "are a more important source of information for scientists than for social scientists and humanities scholars". A number of authors make a connection between this general observation and ICT use in particular. The OECD report (1998, 225) observed that „(t)he impacts of ICT may differ substantially among disciplines, as working practices of scien-

[468] Note that this issue is not meant by the so-called digital divide discussion. Unlike in the present context, digital divide is about inequalities in access between "North and South" and between peripheral and central institutions within the *same* field, not between fields.

tists differ considerably." In computer science, high-energy physics and economics, "digitised information dissemination and retrieval has proven harmonious with pre-existing professional cultures and has provided efficient responses to obstructions in information flows" (Tomlins 1998, 137). Walsh/Bayma compared mathematics, physics, experimental biology and chemistry and came to the conclusion that their data suggests that "fields differ in the extent to which they are changing." These authors conclude that this "suggests that existing social structure is having a substantial impact on the course of change, even with the adoption of technology that can allow fields to converge in structure" (1996, 360).

In an attempt to systematise the various "cultural" or social factors, I shall discuss whether a discipline's (non-)collaborative style, a uniform method or style as part of the common understanding in a discipline, the degree of interconnectedness of a discipline and the publishing traditions add to my overall explanation. By way of introduction, I focus, however, on the general question whether or not these differences play a role even at the level of whole groups or families of disciplines.

3.4.4.1 A general natural science versus social sciences/humanities cleavage?

The hypothesis to be discussed here is the ad hoc feeling that people working in the (natural) sciences are more likely to exploit ICT than those in the social sciences and the humanities. The evidence gathered for this project reveals that the hypothesis cannot be held in these general terms. I looked at those dimensions of "cyberness" discussed above in section 3.3 which discriminate among the disciplines, that is I did not take into account E-mail and groupware use. What can be shown on the most general level is that, on the one hand, the sciences are indeed more "cyber" than the other groups of disciplines in some dimensions – namely with regard to the number of E-journals, E-lists, E-conferences and with regard to hyper- or multimedia publications. On the other hand, they are matched (as regards the use of databases, digital libraries) or even by-passed in other dimensions (namely with regard to virtual institutes and E-archives).

Figure 3-8, I mapped the eight dimensions (E-journals, virtual institutes etc.) in a spider diagram. Each dimension has been translated for each discipline and then, on an aggregated level, for each group of disciplines into a value between Zero and One.[469] "Zero" is in the centre and means that in the respective discipline no experience exists with this feature (e.g. there are no E-journals or virtual institutes). "One" is at the outer end of the spider's legs and represents a maximum. For instance, this means that the highest number of E-journals has been counted in comparison to all other (sub-)disciplines. What can be seen at first sight, is that the line for the natural sciences is not the one most distant from the centre at all corners. In other words, the other groups are more cyber in these respects.

[469] The complete set of values used for the disciplines and groups of disciplines can be found in Table A-1, those for the sub-disciplines in Table A-2 in Annex I.

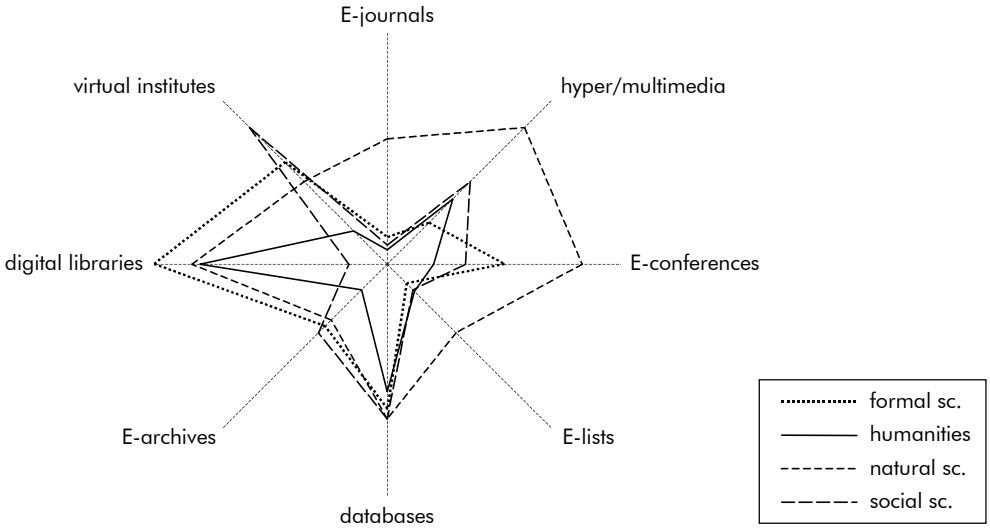


Figure 3-8: Comparison between groups of disciplines: formal, natural and social sciences and the humanities

Note that the above is an extremely aggregated representation of the data which hides important variations within the groups. This brings me to my second observation, which equally undermines the introductory hypothesis. As becomes evident from a direct comparison of, for instance, the natural sciences (see Figure 3-9), the three disciplines included in this study have similar levels in only two of the eight dimensions, namely the use of databases and the spread of hyper-/multimedia publications. Indeed, this comes as no surprise if we take into account that the (sub-)disciplines grouped among the natural sciences are so diverse as high-energy physics and biotechnology.

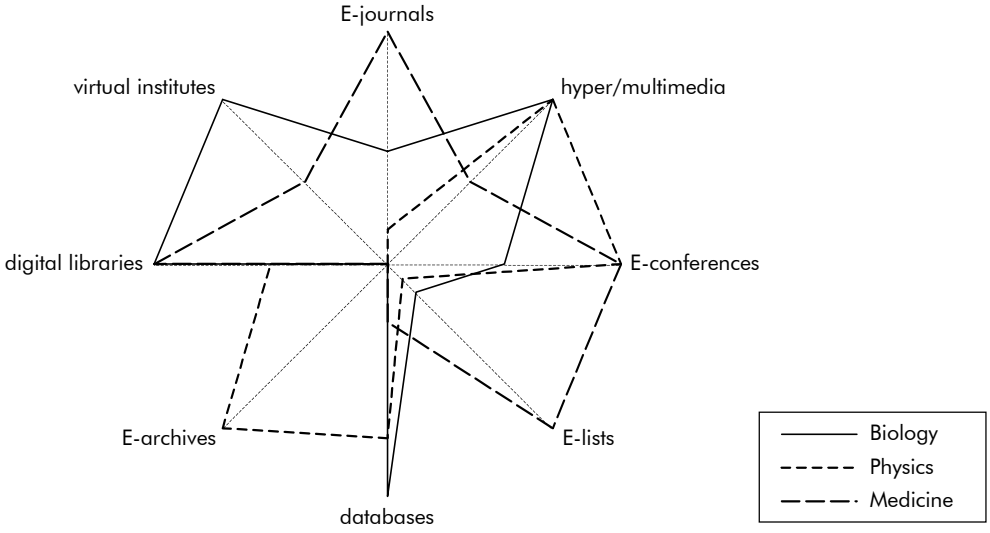


Figure 3-9: Disparities within the natural sciences: biology, physics and medicine

A further strong empirical evidence speaking against the preliminary hypothesis comes from a comparison of disciplines (Figure 3-10) or of sub-disciplines (Figure 3-11 and Figure 3-12) of different groups (families) of disciplines. For instance history and biology differ only in one dimension to a considerable extent, namely when it comes to E-journal numbers (plus moderately with regard to E-lists and databases; see Figure 3-10).

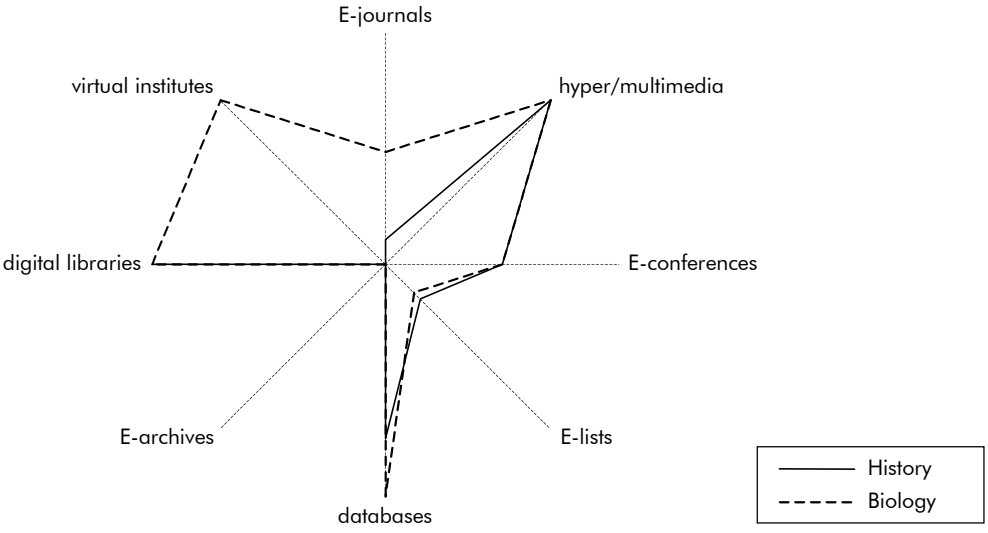


Figure 3-10: Similarities of disciplines of different disciplinary groups: history and biology

Even more striking similarities between fields of different groups of disciplines can be found, when we compare sub-disciplines. Already Figure 3-5 (above in the synopsis 3.3.11) which visualised "cyberness" in two dimensions gives hints in this direction. We saw that in five cases, pairs or triplets of sub-disciplines shared identical scores in both dimensions although they belonged to different groups of disciplines.[470] Figure 3-11 and Figure 3-12 take the same approach as in the rest of this section. They give two selected examples of bilateral comparisons where the two sub-disciplines match each other in six out of the eight dimensions: number theory and analytical philosophy differ only with regard to the existence of digital libraries and the extent to which hyper-/multimedia applications are to be found Figure 3-11). Similarly, early modern history and molecular oncology only differ with respect to the number of E-journals and the proliferation of virtual institutes (Figure 3-12). A similar pair of sub-disciplines from different „worlds" is Latin-American studies and political economy and biotechnology with also six out of eight identical values. Furthermore, there are quite a number of other interesting pairs where five values are still the same.

[470] These pairs are constructivistic mathematics and empirical social research, Pacific studies and fluorescence analysis, tax law and Evo-devo, neurology–pain research and K-theory plus the triplet of applied linguistics, transdisciplinary cultural studies and biotechnology.

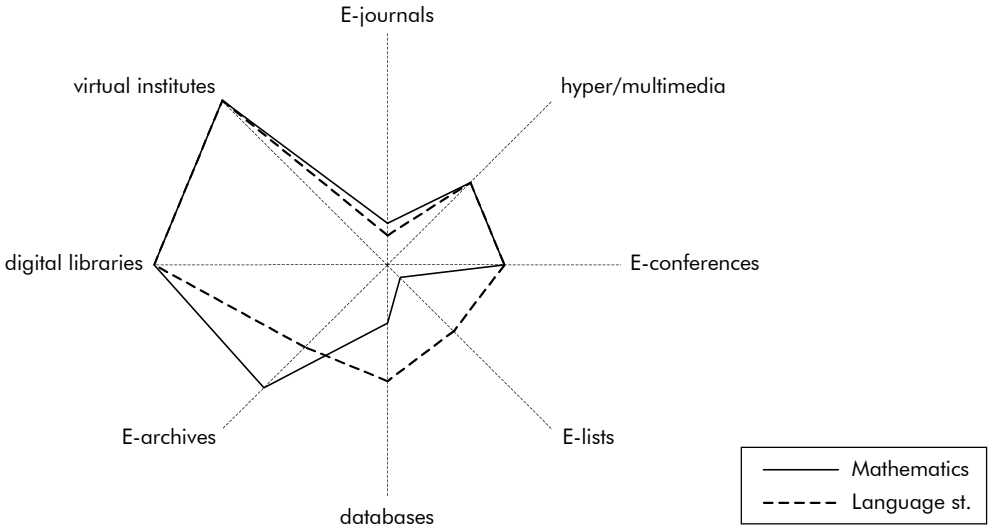


Figure 3-11: Similarities between sub-disciplines of different disciplinary groups I: number theory and analytical philosophy

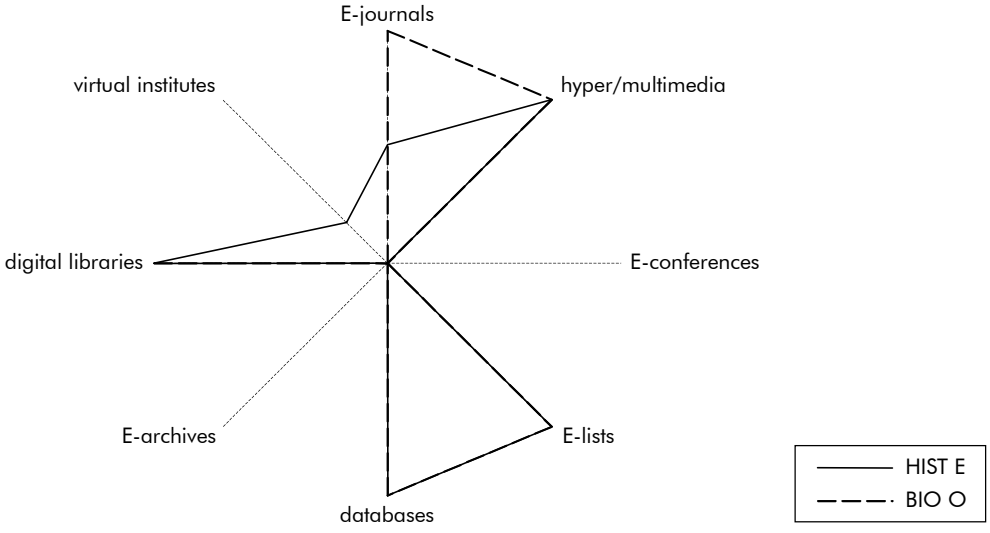


Figure 3-12: Similarities between sub-disciplines of different disciplinary groups II: early modern history and molecular oncology

To sum up, the hypothesis that membership in one of the four large groups of scientific disciplines – natural, social and formal sciences plus the humanities – cannot explain the variations in the degree of "cyberness" between the various (sub-)disciplines. As could be shown, neither the natural sciences are more advanced in the use of ICT in every respect, nor is the picture uniform within the groups of disciplines themselves. Furthermore, both at the disciplinary and the sub-disciplinary level, there are striking similarities between fields belonging to the different scientific "worlds".

3.4.4.2 Collaborative culture, multi-authorship and interconnectedness

Whether a discipline has a rather collaborative style might influence how collaboration practices evolve in the digital age. The more common in a discipline are co-authored papers and multi-author-reports, the more likely intensive use of cyberscience applications (in particular groupware applications) is to facilitate these co-operations. "Those where interdependence is high, with frequent interaction between collaborators, and those where collaborators are likely to be dispersed – such as mathematics, physics and aerospace – are most likely to benefit." (OECD 1998, 199) For instance, Merz (1997) describes the remarkable interconnectedness of high-energy physicists, their communicative needs and collaborative practices and how electronic means have been incorporated, in particular the use of E-mail and E-pre-print archives. The collaborative style is not only relevant for E-collaboration (groupware), but also for writing E-books since this involves complex forms of interaction (Mueller 2000b). Multi-authorship can be a good indicator for a collaborative culture and here great variations are known: "Although philosophers gain greatly from talking with each other, philosophical writings are rarely collaborative." (Thagard 1997a) Many more publications are multi-authored in psychology and cognitive sciences, while in physics, collaborative papers are almost the rule, single-authored ones the exception.

Other authors, such as Hitchcock/Carr/Hall, identify a related concept, namely the "interconnectedness" of a discipline, as the major factor explaining why some STM fields use more E-only journals. In physics and mathematics, there was a culture of circulating papers in advance of refereed journal publication. As for biology, these authors note: "Biologists required access to graphical, often three-dimensional, representations of molecular structures. They recognized the potential to compile databases of these computer-generated images and to make them freely available online. These databases in turn have become a resource that online journals can exploit by linking directly between journal papers and items in the databases." (Hitchcock et al. 1996, 8) By contrast, in computer science, there are "no focal points such as major databases and few established connection structures that can be mimicked and developed online" (ibid., 9). They have "a conference culture which appears to be migrating online, although in an ad hoc rather than any focussed way. (...) The computer science world is certainly physically connected, but the organised information 'interconnectedness' displayed elsewhere has not yet developed to the same degree" as elsewhere (ibid.). Merz describes the interconnectedness of the field of high-energy physics (between institutes, working groups as well as individual researchers) and finds that the field is particularly "susceptible" for intensive usage and quick spreading of E-mail and other Internet facilities. "The entirety of these contact networks which are constantly regenerating and renewing themselves is quasi the social substrate upon which today the Internet (as a technological net) is stretched." (1997, 244, transl. MN) She notes that while telephone calls are rare, incoming E-mail messages structure and stamp the course of the day. Via the Internet existing contacts are being updated and possibly deepened (Merz 1997, 245). E-mail is bridging time and space. Merz (ibid., 259) also notes that the "'impersonal', fully automated E-print archive had predecessors based on the strong interconnectedness of theoretical physicists", namely an extensive system of distributing pre-prints via mail, later E-mail. In the same context, Walsh/Roselle (1999, 68, also quoting Bishop 1994 and own previous research) argue that dispersed and "interdependent" research communities, i.e. "where collaborators need to react back and forth to each other's activities on a frequent basis" will benefit most from ICT.

The following table represents the evidence gathered from expert interviews as regards the collaborative style of the sub-disciplines included in this study. The interviewees were asked to consider both the general spreading of co-operative or team projects, the frequency of multi-authorships in publications and a general sense of interconnectedness.[471]

Table 3-19: Culture of collaboration in sub-disciplines

HIST^{E} PHY^{F} LAN^{S} PHIL^{A} ANTH^{L} LAW^{T}	PHIL^{R} ANTH^{P} LAW^{I}	PAP LAN$^{L, C}$ LAW^{E} HIST$^{A, P}$ MATH$^{K, N}$ ECO^{P}	POL SOC$^{E, S}$ ECO^{E}	ECO$^{M, R}$ PHY$^{H, S}$ SOC^{T} MED$^{C, N, I, T}$ MATH^{C} BIO$^{M, B, O, E}$
no	*rather no*	*partly*	*increasing*	*yes*

On a first level, I compare the spread of E-conferencing (Table 3-5, p. 136) with the general culture of collaboration. I find that all those sub-disciplines with more than isolated examples of E-conferencing score rather high as regards the collaborative culture. The reverse is, however, not the case. Not all collaborative sub-disciplines are already experienced in this type of new collaborative tool. Furthermore, most fields that have many disciplinary databases (Table 3-8, p. 141) are quite collaborative, too.[472] Equally, those sub-disciplines with at least beginnings of virtual institutes (Table 3-10, p. 144) are also those more collaborative.[473] By contrast, E-lists (Figure 3-4) are also popular in less collaborative fields.[474]

On an aggregated level, comparing Table 3-19 with Figure 3-5 (on p. 146) mapping inter alia the scores for "cyber-co-operation"[475] shows that, on average, the more collaborative sub-disciplines indeed make more intensive use of the new opportunities. There are, however, some cases with below average scores despite their collaborative nature. These are thorax anaesthesia (MED^{T}), constructivistic mathematics (MATH^{C}), regional economics (ECO^{R}) and theoretical surface physics (PHY^{S}). Obviously, there are still other factors to take into account to explain this. One common trait of the four is the low dimension of collaboration. The teams are rather small and mainly local. E-mail serves as the main communicative tool. Perhaps, the researchers in these fields do not perceive the need to collaborate with more "sophisticated" tools. As for MED^{T}, I may add along the lines of Walsh and Roselle's argument quoted above that it is not dispersed, but packed (cf. Table 3-12).

By contrast, those sub-disciplines with the highest degree of "cyberness" when it comes to co-operative tools, are all in the boxes for partly or fully "co-operative", in particular

[471] By and large, these results confirm Becher's (1989, 95 ff.) distinction between rural and urban specialities.

[472] The exceptions are two legal fields (LAW$^{T, I}$) and Latin-American studies (ANTH^{L}) where the databases are rather commercial or third-party products than a collaborative endeavour of the researchers in the respective fields.

[473] The exception of the rule is IT law (LAW^{I}) which has been described as rather not collaborative, but with examples of beginning virtualisation. This may have to do with the subject matter which is close to IT studies and therefore more likely to try out new organisational formats.

[474] As groupware is still almost unknown and E-mail is used very widely, both variables are not discriminatory enough to lend themselves for a comparison here.

[475] Remember that this score combines "groupware", "E-lists", "virtual institutes", "disciplinary databases", "E-mail" and "E-conferencing".

high-energy physics (PHY^{H}), macroeconomics (ECO^{M}), social studies of science and technology (SOC^{T}) and American history (HIST^{A}). A similar picture appears if we look at the individual dimensions, in particular at the spread of virtual institutes/collaboratories as well as digital libraries and at the perceived importance of E-lists. Single sub-disciplines do not fit into the picture, but by and large, culture of collaboration and use of co-operative "cyber-tools" correlate as expected.

Remarkably, there is one field with no particular tradition of collaboration which nevertheless scores relatively high in the "cyber-co-operation" dimension: early modern history. All other sub-disciplines in the group of non-collaborative fields score below average in the "cyber-co-operation" dimension. Whether in the case of history, the availability of the new and perhaps easier-to-use "cyber-applications" triggered more co-operation, is an interesting question to be looked at in section 10.3.1.

To conclude, except for a few cases, I can confirm the expected relationship between an (ex ante) co-operative culture and the use of ICT for co-operation.

3.4.4.3 "Cumulative" knowledge production

Beyond co-operation in the framework of particular research projects and a sense of interconnectedness of a discipline, there are research areas engaging in some sort of collective building of "knowledge bases". In other words, the researchers work on different "construction sites" but these belong to an identical "meta-site" – they produce cumulative, interconnected knowledge. By contrast, researchers in other areas work on separated "sites" which are not, or only vaguely, connected. I hypothesise that the former will benefit more from ICT than the latter. In particular, more "cumulative" sub-disciplines should be more likely to produce common databases and digital libraries. Mittelstraß (1996, 27) seems to support this hypothesis when he argues that the humanities have "a healthy conservatism" with respect to their working methods (in the "E-world") because they "do not build a tower of positive knowledge".

The following Table 3-20 lists the answers of the experts with regard to the "cumulative" or "rather non-cumulative" character of their fields.[476]

If we compare these assessments with the spread of digital libraries we find, that indeed, all the sub-disciplines with digital libraries are the ones which "cumulate" knowledge, at least partly. Vice versa (see copy of Table 3-9), we find, however, a few "cumulative" fields which have no digital libraries according this table. As already noted in 3.3.8, the answers included in this table are partially misleading. In particular, economics and physics have, according to my definition, digital libraries (but the experts used another implicit definition). Hence, this leaves us with only mathematics and papyrology as two "cumulating" disciplines with no digital library. However, both fields can be said to compensate this by, in the case of mathematics, E-pre-print servers and central abstracting services, and in the case of papyrology, important disciplinary databases.

[476] Note that this was one of the most difficult questions in the interviews as it needed the discussion of the precise meaning of "cumulative" knowledge production – a difficult concept as such with, in addition, different connotations in the various fields. The above table has to be seen in this light.

Table 3-20: Cumulating knowledge in sub-disciplines

LAN[S] SOC[E]	POL SOC[S, T]	LAN[L, C] PHIL[A] LAW[E, T] HIST[E, P] ECO[P]	ANTH[L]	PHY[H, F, S] PAP ANTH[P] ECO[E, M, R] BIO[M, B, O, E] HIST[A] LAW[I] MATH[C, K, N] PHIL[R] MED[C, N, I, T]
no	*rather no**	*partly**	*rather yes**	*yes**

Table 3-9 (copy): Answers with regard to the existence of digital libraries

HIST[P] ECO[P, E, R] PHY[H, F] MATH[C, N] PAP LAN[S] ANTH[L]	POL SOC[E, S, T]	ECO[M] LAN[L, C] PHIL[A]	MED[C, N, I, T] PHY[S] MATH[K] BIO[M, B, O, E] HIST[E, A] PHIL[R] ANTH[P] LAW[I, E, T]
*no**	*rather no*	*rather yes*	*yes**

Table 3-8 (copy): Spread of disciplinary databases

MED[C, T] PHIL[R]	SOC[E, T] HIST[P] ECO[R] PHY[F] MATH[C, K, N] MED[I] LAN[S, C] ANTH[P] PHIL[A]	SOC[S] BIO[M, B, O, E] HIST[E, A] POL ECO[P, E, M] PHY[H, S] PAP MED[N] LAN[L] ANTH[L] LAW[I, E, T]
*none**	*some**	*many**

Legend for all three tables: Sub-disciplines in* **BOLD *are those marked in all three tables; those* UNDERLINED *are marked in both Table 3-8 and Table 3-20*

Second, the picture is less univocal in the case of disciplinary databases. A field's "cumulative" character does not strongly correlate with many disciplinary databases (see the distribution of **BOLD** sub-disciplines in the copy of Table 3-8). Three sub-disciplines have no such databases although I would expect them according to my initial hypothesis. As to the philosophical sub-discipline, it is hard to conceive what sort of database this might be. As already noted in 3.4.2.3, it may be because of the sensitive nature of the data in the medical field that these sub-disciplines are reluctant to make them available online.

Furthermore, the reverse is more or less the case: Disciplinary databases are, in general, more widespread in "cumulating" or at least "partly cumulating" fields (see the distribution of UNDERLINED and **BOLD** sub-disciplines in the copy of Table 3-8). There are two noteworthy exceptions. Both in sociology and political science, there are many databases, but they are mainly provided by institutions outside academia (not from within the research communities).

To conclude, there is a stronger relationship between the "cumulative" character of a field and the spreading of digital libraries, but only a weaker one with a view to the spreading of disciplinary databases.

3.4.4.4 Publishing traditions in a discipline

It would come as a surprise if the publishing traditions would not add to our overall understanding of the diffusion processes of E-publishing in the various fields. For instance, since books – as compared to journals – tend to be less apt to be shifted to the cyberworld, a discipline with a strong tradition of publishing its results in books is less likely to praise the glory of the Internet. Note, however, that the use of E-mail and the WWW as an archive for pure E-journals has attracted quite some interest and considerable success in the world of book-centred research, such as classical and medieval studies and archaeology (Hamilton/Shory 1997). Surprisingly, a survey of the use of electronic monographs, compared across disciplines (Armstrong/Lonsdale 1998, 40f.) showed equal coverage with no particular subject areas receiving exceptional use of activity.

There are a number of hints in the literature that there are considerable differences with regard to the traditional formats in which scholarly results are formally communicated. In computer sciences, pre-prints are the main means of communicating new results (Odlyzko 1994, 25). In theoretical computer sciences, the proceedings of conferences (normally also published by electronic means) are even more important than journal publications and pre-prints (ibid., 27). Talking about the natural sciences, the Pew Higher Education Roundtable (1998, 7) observes that it was "only a slight exaggeration to say that by the time a piece of work reaches the printed page its greatest research impact has already occurred, and its remaining value is primarily archival." Similarly, Thagard (1997b) argues that the problem of less stringent or no quality control when it comes to pre-print archives "may turn out to be more acute for psychology than for physics whose journals have lower rejection rates than psychology journals: a physics paper is probably going to end up published anyway." When retrieving information from bibliographic databases, researchers from different disciplines behave differently. Based on an empirical study David/Zeitlyn (1996) come up with the following typology: (a) the authority of the author in philosophy;[477] (b) the authority of the laboratory, i.e. the communicating team surrounding each researcher, in chemistry; (c) and the authority of the technology in economics. Bourguignon (1999, 109) observed that mathematical (abstracts) databases are a basic working tool and that "mathematicians use their publications in a different fashion to other scientists". Tomlins (1998, 139) argues that at least part of the motivation of scholars to overcome the present system of journals "derives from what are not simply inefficient, but positively oppressive, practices associated with traditional or mainstream modes of publication and dissemination" (in law and in the natural sciences). But, he adds, this is not paralleled to the same extent in the humanities and social sciences. According to a Dutch empirical study (Rusch-Feja 1999), the transition from printed to E-journals is definitely discussible in economics, but not in law. The same study already showed strong differences between the academic disciplines included (economics, medicine, law) with regard to the use of printed journals. Among other results, medical and economic researchers attach much value to the existence of an abstract, lawyers don't.

With a view to exploring the initial hypothesis that journal and book-centred disciplines react differently vis-à-vis E-publishing, I asked the experts three related questions: First, what the overall status of books is in the sub-discipline, second, how fre-

[477] "(T)he use of electronic databases in developing a bibliography in a new field [of philosophy] was seen as a paradoxical process by many who did use them, and as largely unhelpful by the majority." (David/Zeitlyn 1996, 6.5)

quently older literature is quoted, and third, whether it is necessary for a career in the field to have written a book. The following table summarises the answers:

Table 3-21: Status of books

Older literature quoted		Low	medium	high
	frequently		SOC[S] MATH[C, K]	PHIL[R] **PHIL[A]** **PAP** **LAN[S, L, C]** **ANTH[L, P]** MATH[N] SOC[E, T] **HIST[E, A, P]**
	partly	BIO[M] PHY[F, S]	ECO[P] **LAW[I, T]**	**POL** PHY[H] **LAW[E]**
	seldom	BIO[B, E] ECO[M] **ECO[R]** MED[N]	MED[T]	
	never	BIO[O] ECO[E] MED[C, I]		
		Status of books		

Legend: The sub-disciplines in **BOLD** *are those where having written a book is necessary for a career in the field*

First, we compare the above table with Figure 3-5, which lists all sub-disciplines inter alia with regard to the cumulative score called "cyber-publishing". Surprisingly, the sub-disciplines in the upper-right box of Table 3-21, i.e. those where books have a high status and are frequently quoted, spread almost evenly from the lowest to the highest score in "cyber-publishing". North-American history (HIST[A]) with the highest score is a book-oriented field as is Latin-American studies (ANTH[L]) with the lowest. It may be that in this case the cumulative score is too much aggregated to reveal interesting details. Note as well that whether having written books is even necessary for a career in the field, seems not to have any influence. Many of these fields have high scores in the "cyber-publishing" dimension (for instance applied linguistics).

Therefore, we look in a second step at the prestige of E-journals in the book-oriented sub-disciplines:

Table 3-3 (copy): Prestige of E-journals

PAP SOC[S]	**SOC[E, T]** PHY[F, S] **LAN[S]** **ANTH[L, P]** BIO[M, B, O, E] **PHIL[A]** MATH[C] MED[C, I, T] ECO[P, E, M, R] LAW[E, T]	POL **HIST[E, P]** MED[N] **LAN[L]**	PHY[H] **MATH[N]** **LAN[C]** LAW[I] **HIST[A]**	**PHIL[R]** MATH[K]
(E-j. non existent)	*low*	*low, but growing*	*medium*	*high*

Legend: Sub-disciplines in **BOLD** *are the most book-oriented fields according to Table 3-21*

Indeed, the prestige of E-journals is low in most book-oriented fields. There are, however, four noteworthy exceptions. Ethics in risk-research (PHIL^{R}) seems to be a special case, as it is a rather non-traditional philosophical speciality which is very close to risk-research, a predominantly technical or natural science field in which books do not play an important role. This might have had an influence on the high prestige of E-journals despite the book-orientation. The mathematical sub-field number theory (MATH^{N}) is today closely related to the Internet as it serves as the basis for cryptography, hence there is an applied side of widespread interest in the Internet community. It is likely that this is the reason for the importance of E-journals in the field. Furthermore, mathematics was never a purely book-oriented discipline. Most research results are published in journals. Books may be called the synoptic archives of the mathematical journal literature. Trans-disciplinary cultural studies (LAN^{C}) are a relatively new speciality, which almost co-developed with the Internet. This might have influenced the positive stance towards E-publishing despite an underlying book-orientation of most of the fields coming together under this label. The remaining exceptional case, North-American history (HIST^{A}), does not only score high in this respect (and the dimension "cyber-publishing" in general), but also very high with regard to "cyber-co-operation" (cf. Figure 3-5). On its path to cyberscience, this field is obviously about to leave behind the older book-oriented tradition.

Third, we note that the book-oriented disciplines are not among those fields with high numbers of P+E-journals (cf. Figure 3-2). By contrast, those fields just discussed as exceptional in the previous paragraph have relatively many E-journals ("beaten" only by the life-sciences, which are not at all book-oriented).

Fourth, as expected, almost all of the book-centred fields have no important pre-print culture (cf. Table 3-7). One of the exceptions is, again, number theory (MATH^{N}). The same arguments as developed above with a view to E-journals should also apply here to explain this case. The other two cases are applied linguistics (LAN^{L}) and social science studies of technology (SOC^{T}). As to the latter, a special affinity of the researchers to technological innovations may be due to their continuous preoccupation with new technologies. Also the former seems to be a special case which cannot be explained on the basis of the variable book-orientation.

Summarising these results, we have to conclude that there is indeed a relationship between the book tradition of a field and its assessment of E-publishing. There are, however, examples of fields that explore E-publishing despite their original book orientation. Whether this is an indication of the persuasiveness of E-publishing, has to remain unanswered here, but will be discussed in 7.3.2.

3.4.4.5 Discipline-wide uniform method, style and paradigm

Whether a uniform method or style is part of the common understanding in a discipline (and hence all are "socialised" in the same kind of discourse) or whether fundamental disagreements of method, style and research paradigms are a substantive part of the field itself, might impact on the likely system and format of publication and quality control. For instance, Okerson/O'Donnell (1995, Conclusion) ask whether a system of self-publishing as practised in some disciplines could be transferred to other disciplines when fundamental disagreements of method and style are a substantive part of the field itself. They contrast the situation in physics and mathematics where there is a "well-defined group of users, all acclimated to the same kind of discourse".

Table 3-22: Uniform method and style in sub-disciplines

PHIL[R] HIST[E, A] LAN[S] POL SOC[T] BIO[B]	LAN[L] PHIL[A] ANTH[L, P]	ECO[R] MATH[C] SOC[S] HIST[P] LAN[C]	ECO[P, M]	MATH[K, N] PAP SOC[E] BIO[M, O, E] ECO[E] MED[C, N, I, T] LAW[I, E, T] PHY[H, F, S]
no	*rather no*	*partly*	*rather yes*	*yes*

The above table lists the respective expert answers. Indeed, those sub-disciplines in which no uniform method or style is required have no E-pre-print system (cf. Table 3-7). Furthermore, in the "uniform" group we find a number of sub-disciplines that have settled with an E-pre-print system, in particular economics and mathematics. However, although in this group, other fields have not adopted such an E-pre-print system. This is not surprising, as these other fields never had a strong pre-print culture.

It seems that the hypothesis might be able to add to our understanding[478] why the social science studies of technology (SOC[T]) did not adopt an E-pre-print server system: it may be a too heterogeneous group. At the left end of the above table, I am puzzled with the fact that European studies (POL) have a central E-pre-print archive. Again, the same supplementary explanation as with SOC[T] might apply, namely that it is also a matter of an activist triggering the development (see below 3.4.5.1).

To sum up, uniformity of a sub-discipline in terms of methodology and style favours the establishment of an E-pre-print system in those cases where there was a pre-print culture beforehand. The lack of such uniformity may be the reason why fields with P-pre-prints do not establish an E-version.

3.4.5 Agency

Apart from the factors playing at the levels above the individual researcher or institution, I could detect two drivers at the actor level (cf. 1.2.3.3): very active researchers and renowned institutions can both make a difference in the overall performance of a speciality.[479]

3.4.5.1 Cyber-entrepreneurs

The history of innovation has highlighted the importance of the presence of entrepreneur-minded researchers in a field – that is opinion leaders and innovation champions (Rogers 1995, 354ff.).[480] Many of the outstanding developments like the WWW itself or the first E-pre-print archives would not have been such, or so early, a success if there had not been a few driving individuals. The existence of a few, very active entrepreneurs with exciting ideas promoting the use of ICT applications may change the tide. Hitchcock/Carr/Hall acknowledge the importance of eminent and influential scientists when comparing

[478] See also below 3.4.5.1 on cyber-entrepreneurs.

[479] Another individual factor playing an indirect role here, too, is the personality of the founder(s) of a speciality. Some specialities are organised like a network, others are more centred around the original founder(s). In the second case, it is likely that the personal preferences of the founder or core group influence the communicative and collaborative culture of the whole speciality.

[480] Cf. 1.2.3.3.

the development of E-journals in STM disciplines and found out that, in 1995, there was not yet such a prominent computer scientist "prepared to champion new electronic publications in the face of the current dilemmas, doubts and divisiveness" (1996, 9). There seems to be "the necessity of the presence of heavy users to develop electronic communities [because t]hose users' positive perception of the medium encourages exchanges and relationships" (Hert 1997, 342, quoting Bayma 1995).

Table 3-23: Cyber-entrepreneurs

SOC$^{E, T}$ ECO^{P} PHY^{S} MED$^{C, I}$ PHIL^{R}	BIO^{E} ECO^{E} LAN^{S}	MATH^{N}	MATH$^{C, K}$ SOC^{S} ANTH$^{L, P}$ HIST$^{E, A, P}$ ECO$^{M, R}$ PHY$^{H, F}$ POL LAW$^{I, E, T}$ PAP MED$^{N, T}$ BIO$^{M, B, O}$ LAN$^{L, C}$ PHIL^{A}
definitely no	*rather no*	*rather yes*	*definitely yes*

Not all sub-disciplines have their heavy users and activists. However, comparing the above table with both the general "cyberness" scores and the scores in the individual dimensions produces no conclusive results. We always find some of the fields with definitely no "cyber-entrepreneur" in the "head" group of one of the dimensions. For instance, fluorescence analysis (PHY^{F}) seems to have very important E-lists; political economy (ECO^{P}) participates in a central E-pre-print server and has virtual institutes; ethics in risk research (PHIL^{R}) has digital libraries; and social science studies of technology (SOC^{T}) scores very high in the dimension "cyber-co-operation". From this, I have to conclude, on the one hand, that the activity of cyber-entrepreneurs is not a necessary condition for the widespread adoption of cyber-applications in a field. Indeed, as we have seen in the previous sections, there are a number of concurrent or complementary factors, which may play a role in the particular setting of sub-discipline. It was, however, to be expected that individual factors would not play a *general* role.

On the other hand, there are many particular examples where obviously the presence or absence of researcher-activists was indeed a key factor for the state-of-the-art of ICT use in a field. Given the, in general terms, rather conservative approach of a field like papyrology, it comes as a surprise that this tiny group of researchers is in command of one of the best organised online database systems to help the community. The interviews revealed that this traces back to the dedicated efforts of a few papyrologists. Beyond any doubt, there have been no such entrepreneurs yet in Slavic studies (LAN^{S}), although a digital library or an online review journal could certainly be attractive for this community (similar to German studies in the US, for instance). A web portal like the one serving the community of Europeanists (POL, ECO^{E} and LAW^{E}) – including a working paper archive, an interactive, community-updated link collection and an E-journal – would definitely not have seen the light of the virtual day, if not made possible and developed by activism from within the research community. By contrast, it seems likely that the lack of a cyber-entrepreneur in the social studies of technology (SOC^{T}) explains that there is no E-pre-print archive despite the high importance of pre-prints in the field. Talking of E-pre-print archives, both the first physics archive and its followers in other fields, like cognitive sciences, are closely connected to persons well known in those research communities (and beyond). This is, however, not to say that it was only the activism of Ginsparg, Harnad and others which made it possible. Above all, a strong tradition of ex-

changing pre-prints which was about to hit its limits of feasibility in the P-world was certainly a pre-condition for the swift move of a whole community to the new E-based system. Nevertheless, it had to be done by someone despite the lack of any institutional decision to do it.

In conclusion, the individual factor "cyber-entrepreneur" cannot explain all or even a majority of cases of strong ICT use in a discipline, and vice versa, low degrees of "cyberness". However, this factor helps to understand particular cases, which would otherwise remain a puzzle.

3.4.5.2 Reputation

There is another individual factor beyond activism. While it may well be that a previously unknown activist gains reputation because of her or his activism, at the end of the day, the success of the activity may not only depend on the technical or organisational brilliance of the implementation, but on the reputation of those joining the rolling train. For instance, Wellman/Minton (1998, 8f.) point at the vital importance of the substantial participation of leading researchers in their field for the success of an online journal project. Also the reputation of the editing institution as a whole may be the key. This can, however, be of varying importance in the different fields, as Okerson notes:

> "The field of high energy physics is well defined by the laboratories where work gets done, and there is a kind of quality control exercised by readers who note where given papers come from and choose how to apportion their reading time appropriately. That is a facility that would not be so easily obtained if the field were, say, nineteenth-century English literature, where a small state college may produce work as reliable as large, well-endowed institutions do." (Okerson/O'Donnell 1995, Introduction).

In any case, even if starting bottom-up, that is without the participation of the rank and file of a research community, an initiative to introduce an E-tool will only be successful on a larger scale as soon as it is recognised by the hierarchy. As for an E-journal, increasing rates of manuscript submissions to the E-journal and references to it by senior and leading researchers may signal recognition. Equally, an E-pre-print system, E-conference or E-journal will have a head start where its editors are "big shots" or central research institutes.

Several interviewees pointed at the absence of senior members of the community in these projects when describing the low prestige of E-journals. The two unsuccessful attempts to found E-journals in anthropology reported by the interviewees may be explained in terms of the peripherality of the editorial institutions. The activities of the editors of the interdisciplinary E-journal in European integration research to establish a reputation were not equally successful in the various disciplinary communities. While the political science community welcomed the journal and even the leading researchers in the field publish there and serve as referees, the situation is different for economics and law. Only very few submissions from the latter fields are received.

To sum up, it is less the reputation of the initiators, but of the early users and supporters which lends legitimacy to any E-project, in particular to E-publishing ventures.

3.5 Summary

In this chapter, I analysed the status quo of the use of cyberscience tools and applications in 36 sub-disciplines across all disciplinary "families". In a first step, I studied the individual sub-disciplines in the form of case studies (3.2), and in a second step, I looked at ten dimensions of "cyberness" in a cross-disciplinary comparative view (3.3). The result of this first part, summarised in a synoptic chapter, was a picture of great variation. In the second part of this chapter, I explored a number of hypotheses derived from my conceptual framework (3.4) to shed some light on this variation and its roots.

As we have seen, ICT use or "cyberness" is a multi-dimensional concept. Additionally, we have a number of units (working groups, institute, speciality, sub-discipline, discipline, family of sciences) in which the concept may impact differently. As expected (see 0.1.2), I could not find univocal causal relationships, as required by King/Keohane/Verba (1994) and others. Similarly, the method of qualitative comparative analysis (QCA, see Ragin 1987; 2000) does not lead me too far because we witness the presence of a multi-causal relationship between the disciplinary factors and the level of ICT use in the various academic fields. This seems typical for much social science research: Neither a single factor nor any combination of a small number of factors is able to explain the variation. Obviously, most of the factors do play some role, but they influence the impact of each other. I hold that none of these factors is either necessary (in the sense that its presence is a pre-condition for a particular level of ICT use) or sufficient (in the sense that it alone can explain why a particular sub-discipline has a specific level of ICT use). Notwithstanding this situation, it should be possible to draw a coherent picture of the factors and their explanatory force depending on specific circumstances. The remainder of this chapter will do just this.

In a first step, I pull together the overall conclusions of the sub-sections of 3.4 in the following Overview 3-3:

Disciplinary factor	Impact on	Correlation in practice	Comment
Smaller size	More "cyber-co-operation"	No	Exceptions (PAP)
Smaller size	More E-publishing	No	Exceptions (LAN)
Size dynamics	More "cyber-co-operation"	No	
Author-reader ratio	More E-pre-print servers	No	
More dispersed	More "cyber-co-operation"	Rather no	
More embedded	Less "cyber-co-operation"	No	
More visually oriented	More multimedia	Yes, partly	
Rendering problem	Less ICT (e.g. multimedia)	Yes	E.g. MATH, ornithology
More data-dependent, model-driven	More disciplinary data-bases, more virtual institutes	Yes, partly	
Higher time pressure, faster pace of discovery	More E-journals	Yes	
Higher time pressure, faster pace of discovery	More E-pre-prints	Yes, partly	

Disciplinary factor	Impact on	Correlation in practice	Comment
International focus of research	More ICT use	Rather yes	But all fields are increasingly internationally oriented
Closer to economic application	Less E-pre-prints	Yes, partly	Counterexamples ECO, LAN^{L}
Closer to economic application	Less disciplinary databases	Yes, partly	Counterexample BIO
More competitive	Less "cyber-co-operation"	No	
Less funding	Less ICT use	Yes, partly	E.g. LAN^{S}, counter-example MED^{T}
Natural sciences vs. other disciplinary families	More ICT use	No	
More collaborative	More E-lists	No	
More collaborative	More E-conferences	Yes, partly	
More collaborative	More disciplinary databases	Yes	Some exceptions
More collaborative	More "cyber-co-operation" in general	Yes	Some exceptions
More cumulative tradition	More digital libraries	Yes	
More cumulative tradition	More disciplinary databases	Yes, partly	
More book-oriented	Less "cyber-publishing"	No	
More book-oriented	Lower E-journal prestige	Yes	Counterexamples (e.g. HIST^{A})
More book-oriented	Fewer P+E-journals	Yes	Exceptions
More book-oriented	Less E-pre-prints	Yes	Exceptions
Pre-print culture	More E-pre-print	Yes	Exception SOC^{T}
Uniform style or methods	More E-pre-print	Yes, favourable	If pre-print culture beforehand
Successful cyber-entrepreneurs	More (innovative) ICT use	Yes	Helps understanding individual cases
More reputation of editors and authors	More successful E-journals	Rather yes	

Overview 3-3: Explanatory power of disciplinary factors

The above overview shows that there are only few univocal relationships between the disciplinary factors and the individual or general dimensions of "cyberness". The next overview lists, on the basis of the above, only those factors which turned out to be at least partly influential in the various dimensions:[481]

[481] Note that if this overview lists only one influencing factor (as, for instance, in the case of "digital libraries") this does not mean that this factor is the only determinant (in the sense of mono-causality). Furthermore, those factors listed for the general dimension "ICT use in general" (last line) also play a role in the non-aggregated, single dimensions above.

Dimensions of "cyberness"	Influencing factors
E-pre-print servers	+ Uniformity of style or methods + Pre-print culture (+) Time pressure (+) Pace of discovery – Book orientation (–) Closeness to economic application
E-journals	+ Time pressure + Pace of discovery (+) Reputation of editors (–) Book-orientation
Digital libraries	+ Cumulative tradition
Multimedia	(+) Visual orientation – Rendering problem
Disciplinary databases	(+) Data-dependent, model-driven (+) Cumulative tradition (+) Collaborative culture (–) Closeness to economic application
E-conferencing	(+) Collaborative culture
Virtual institutes	(+) Data-dependent, model-driven
ICT use in general	+ Cyber-entrepreneurs (+) International focus (+) Funding

Legend: + ... positive influence; – ... negative influence; ( ) ... partly

Overview 3-4: Influencing factors for "cyberness"

Summarising these results, we find that a few factors turned out to play a more than marginal role when it comes to explaining the still considerable differences between the various academic fields. In particular, as I analyse the influence of communication technologies, it comes as no surprise that a sub-discipline's collaborative culture is important. Equally, a pre-existing pre-print culture strongly favours the establishment of E-pre-print servers. A general time pressure and faster pace of generating new results let researchers be more open to new forms of cyber-publishing. In general, more book-oriented fields are less inclined to go for E-pre-print servers and E-journals. A field's cumulative tradition both favours digital libraries and disciplinary databases. Whether a subject area is data-dependent and model-driven impacts on the likelihood of many disciplinary databases and virtual institutes. Closeness of the field to economic applications has a negative influence on the existence of both E-pre-print servers and disciplinary databases. Sub-disciplines applying more uniform styles and methods are more likely to favour E-pre-print servers. As regards multimedia, more visually oriented fields are at the forefront, but so far, technical rendering problems hamper its success. On a general level, it can be said that better funding and a more international focus of the research field favour ICT use. The existence of cyber-entrepreneurs may further account for the general level of ICT use in a speciality.

As expected, I cannot identify a set of variables that could explain all cases. It is rather the varying combination of a number of them, which contribute to an overall explanation. The remaining exceptions can be mostly explained *ad hoc*, making reference to special characteristics of the respective field. Furthermore, historical contingencies, like the influence of particular personalities, play an important role, too. In addition, I was able to discard a number of – at first sight plausible – hypotheses put forward in the literature. In particular, a cleavage between the natural sciences and the humanities or social sciences cannot be confirmed. This leaves us with a colourful snapshot of the status quo and its roots.

***

In Part Two of this study, we have first looked at the great variety of new tools and technological opportunities in the age of cyberscience, followed by an analysis of the current status quo in a few selected fields. The following Part Three will be devoted to an in-depth discussion of the consequences of this status quo. I shall start with the impact on the spatial layout of academia in the following chapter and continue with the impact on role distribution, new forms of knowledge representation, electronic publishing, quality control and finally economic and legal aspects.