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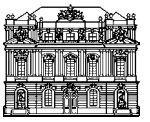
cyberscience

Research in the Age of the Internet

Chapter 10

CYBERSCIENCE AND THE SUBSTANCE OF RESEARCH



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"A growing number of colleagues testify that a few weeks of being active on the networks changes one's working life." (Okerson 1991b, 18)

10 CYBERSCIENCE AND THE SUBSTANCE OF RESEARCH

Based on my analysis of the status quo,[901] there can be no doubt that at the beginning of the 21st century researchers in almost all disciplines work quite differently than only some twenty years ago. In most academic offices, the computer has replaced the typewriter, the phone rings less often than the E-mail programme reports new messages in the in-box folder and many of us have got acquainted with the pleasures and woes of retrieving information through the Internet. This list of obvious changes could be extended easily, but the question I want to approach here is whether these have the potential to influence the content of the research. In other words, does the application of ICT in academia affect *what* actually comes out of the activity of researchers as opposed to *how* it is done?

10.1 Introductory remarks

There is not much in the literature trying to directly address this question yet. Some authors seem aware of the issue, but rather focus on different aspects. On a general level, it has been argued that "all remembering occurs in a given context. And this context fundamentally alters the content of what is remembered" (Brown 1999). Speaking of hypertext and computer writing, Birkerts (1997, 213) notes that a change in the work modes necessarily impacts on the results, at least in a weak form. Translated to our subject here, ICT and in particular web archives, E-mail digests, groupware shared space and the like will impact on what researchers actually process and hence on what grounds the results are based.[902] The Internet may be seen as contributing to a growing together of different, previously independent intellectual traditions and hence to new solutions (cf. Starbuck 1999, 190). Fuller, in the context of discussing peer review and authorship in the new medium, acknowledges "technology's potential to shape thought" (1998, 128). Some argue that the impact of the new forms of scientific work organisation (multi-site work teams etc.) is not yet clear, but it is implied that increasing sub-field fragmentation (cf. 4.3.5.3) may indeed have an impact (Walsh/Roselle 1999, 57). Speaking of publishing, others argue that "(i)n principle, paper and electronic media need not influence the scholarly quality of a book or journal. But paper and electronic media do have significantly different material properties, and that influences some of their social properties." (Kling/Covi 1995) When elaborating this point, however, these authors do not so much focus on the social properties, but more on the evolving working patterns. A number of interesting points about the impact of the computer and the networks on intellec-

[901] Cf. in particular chapter 3 and the first sections of chapters 4 to 7.

[902] By contrast, in his case study on cold fusion, Lewenstein (1995) analysed the communicative patterns in a USENET newsgroup (qualitative content analysis) with a view to finding out whether this contributed to the creation of scientific knowledge. He comes to the conclusion that it did not. I hold, however, that the evidence is limited to one particular case.

tual and scientific work are raised in a short paper by Geser (1996). He distinguishes between self-related, interpersonal and institutional sources of intellectual work and discusses briefly ICT-induced changes for all of these sources. By contrast, the still ongoing projects of Berkowitz (2002) and Vasileiadou (2002) intend to elaborate more systematically and in extended form on the impact of the new medium on the content of research.

Before I continue the analysis, I need to make clear what I am not dealing with here: First, I am not interested in the fact that a number of research fields are centred around ICT itself and have made the analysis of social behaviour in the Internet, of technical aspects of the new communication structures and media or of the consequences of ICT in their field (e.g. in economics or law) their research topic. For instance, in the new field of Internet research the impact of the Internet on this field's content is obvious, but at the same time trivial. By contrast, I am interested in the impact on outcome whatever the topic.

Second, I am equally not focussing here on how the computer as such has enabled new ways of doing research (cf. 1.2.1.1). This can be observed in the formal and natural sciences, but also in the more quantitatively oriented social sciences (e.g. in economics) where a growing number of research questions could not even be answered from the start without the help of computing power. Furthermore, one cannot deny that, first, virtual reality might simulate non-human perceptions; that, second, our intuition would develop "if we could equip ourselves with different sensors such as gravity sensors, that are suggested to exist in plants, the magnetic memories of sea turtles [or] with the electric senses" (Kircz 1998a, 5); or that, third, massive computer-based simulations and experiments are perhaps the most important epistemological progress in the scientific method since the invention of accurate time measuring devices (Dennett 1997, 238; Coy 1999). Take the example of molecular biology, for instance, where the "drylab" that is a laboratory without "wet" apparatus but instead with computer equipment simulating experiments, is gaining in importance. Even in the text producing disciplines, the computer has brought about considerable change: writing on screen with all the opportunities of easy editing, moving around chunks of text and displaying the structure of the text is a completely different experience than writing by hand or with a typewriter (cf. 6.4.1.1). However, here I am focussing on changes brought about by communication technologies.

What follows is the first attempt to systematically map the possible consequences of ICT on the substance of research (as defined in 1.2.4.3). We can distinguish between three main groups of such consequences, namely those effects which are due to ICT-related changes in methodology (10.2), due to changes in work modes (10.3), and finally due to changes on the level of knowledge representation (10.4).

The question asked in this chapter is possibly the most difficult of all to tackle in our context. How to compare unique scientific results either achieved in a traditional or a cyber-setting with the output of a hypothetical project of the opposite formation? There is no direct way to get empirical data on this since it is impossible to carry out a research project in two parallel experiments with the same[903] persons. Therefore, I am bound to ask researchers about their experiences and analyse the likely impact of the technology by comparing previous and current research while respecting the impossibility of direct comparison (cf. already 0.3.4). This chapter, therefore, builds both on analysis already included in previous chapters (in particular in chapters 4 to 7) and on empirical evidence newly introduced here (from my interviewees, see questions 51 to 72 as listed in Annex III).

[903] It would be essential to have the same researchers performing in two different ways because the impact of individuality seems very important in research.

10.2 Effects due to changes in methodology

One obvious mechanism how changes in the scholarly communication may impact on outcome is via methodology. How new knowledge is created in a scientifically accepted way often involves communication whereby all three layers of communication are affected (Gibbons et al. 1994, 36ff.).

10.2.1 Outcomes, otherwise impossible

ICT is opening up new ways of producing results, which could not have been produced before. The argument here is not that different results are being produced, but that they *are* produced at all. In other words, these outcomes would otherwise be impossible, that is not feasible without ICT. Note that "impossible" has to be understood here in a broad sense including alongside impossibility in principle also practical impossibility due to restrictions of time and money. Obviously, this will be different in the various research fields. Indeed, many of my interviewees said that, in their field, ICT is not capable of producing new results. However, the following for groupings exist for such innovation:

- *Access to data*: In many circumstances, projects would not have been carried out if getting the necessary data had not been so easy due to remote, dispersed archives and databases for country or regional comparisons in the social sciences (e.g. panel studies, combining time series and cross-sectoral studies in economics). Comparative research and transnational questions are favoured. Another example is the online availability of legal acts, which allows for statistical analysis of growth of legislative activity by political scientists. Furthermore, legal scholars seem to be more inclined to access a text in the original language if access is easy. Also in molecular biology, the combined computing of data of several sequence databases opens up new research questions. The same is true in papyrology where cross-database full text search has led to new activity areas of papyrologists. One interviewee summarised that if a certain piece of information is not available in due time, it cannot be used, whereas if it is easily available, it will be used and we have to expect that the substance is altered.
- *Distributed computing* (see 2.2.1) enables researchers to fulfil tasks that would take much too long for single computers (or even local clusters of computers). Prime examples come from chemistry and mathematics, other fields may follow suit with a view to computing world-models (e.g. climatology, astronomy, economics).
- Software for administering large *Internet surveys* allows for new ways of reaching research subjects around the globe and is transforming and revolutionising (Bainbridge 1999, 124) the methodologies of the human-related disciplines. Although today such surveys have the disadvantage that they cannot potentially reach everyone (as access to the Internet is not universal), this is likely to change in the future. In addition, "appropriate techniques can be developed to compensate for non-randomness of the samples" (ibid., 128). Furthermore, web-based surveys allow for dynamic "on the flight" analysis of the data as the input flows in in digital format.
- *Shifting the work through time zones* may in some cases be a conditio sine qua non for a project to be carried out (cf. 4.3.2.2). An example may be the co-ordination of projects in astronomy where scanning of a particular stellar region needs to be handed over from one observatory to the next.

- *(Distributed) databases as solution to new challenges*: In some fields, e.g. in molecular biology/biotechnology, recent advances in methodology have led to an enormous increase of raw data produced. While these advances are not directly related to new communication technologies, large distributed databases were nevertheless the solution to the problem of how to deal with raw data efficiently and productively.

To sum up, there are scientific results being delivered in the age of cyberscience which would not have been possible without the help of ICT.

10.2.2 Initial input changes

> "(I)ntellectual work may experience radical change when computers are linked to libraries, data banks and other institutions in order to provide access to publications, legal documents, statistical data and other kinds of 'formal' information."
> (Geser 1996, 9)

One of the most striking features of the emerging mode of doing research in the cyberscience age is the improvement of direct access to relevant information. It is to be expected that sooner or later almost all written information necessary for research (in most fields) will be available online. Other material such as pictures, numerical data, audio or video files will follow suit.

The networked environment with its multiplied opportunities to access and filter information[904] may lead to a different starting point or initial input side of research. My interviewees almost univocally agreed with the thesis that cyberscience changes these starting conditions. This might be positive and negative at the same time: on the one hand, it may lead to a broader basement of research. Research will start with more up-front information available and will be more broadly founded in the existing literature as well as empirical data. For instance, literature surveys are likely to be more comprehensive (bibliographies become larger).[905] Another effect mentioned by my interviewees was that this triggers more variation, more selection opportunities, more information turn-around. For instance, it seems that cyberscientists are more inclined to use grey literature, that is not formally published papers and pieces of information found in the WWW. Furthermore, structured full text databases with appropriate search-tools in place may help the researcher "to make a navigation chart, and avoid hazards, waste lands and culs-de-sac" (Davenport/Cronin 1990, 182).

On the other hand, selection opportunities may also be interpreted in a negative way: the input may simply be too much to process adequately (problem of *information overload*[906]). One interviewee pointed at the danger that the scientific products may become

[904] Hartmann (2002, 262) speaks of the "new cultural topology of distributed knowledge".

[905] Note, however, that in many research areas the initial input plays a minor role as the main thrust of information used in the research is only produced during the research itself, e.g. in the case of field research, interviews or experiments. Here the influence of initial input on content is naturally restricted. Also in philosophy, valuable books can be written with reference to only one other book in the bibliography.

[906] This problem may, however, be diminished in the future with the help of technical solutions like filtering based on meta-information, cf. 2.2.2. On the issue of information overload in general, see 6.4.3.2.

less concise and even spoke of the danger of stasis. The online availability of full text may lead to less original work when copying and pasting quotes into a new piece without much value added. Mittelstraß, a philosopher, argues that information technologies will not help much in the humanities (and elsewhere) since too much information, although easily accessible at one key stroke, is rather inhibitory for research than promotional because this is not the way our brain works (1996, 28f.). Therefore he asks for the preservation of the unforeseen which is crucial for research. I think, however, that Mittelstraß has underestimated the potential of hyper-browsing through the new electronic information bases. The human mind is "clearly capable of making multiple linkages and connections, and since the social world itself requires flexible and multi-faceted analysis, then the creative integration of different media may offer the reader and analyst a more adequate approximation of the richness of (...) knowledge." (Dicks/Mason 1998, 6.5)

Furthermore, in the present time of transition, the selection criterion may be *biased towards availability through the electronic networks*. The early cyberscientist may remain negligent of literature and information that is not online. This has two aspects: First, keyword search in databases will let the cyberscientist find only what has been keyworded and indexed. How we will be "browsing" for information is about to change: we will not find the book shelved next to the one we were searching for any more because there are no physical shelves any more. In exchange, we might find other resources that were given the same keyword. Second, as regards access to full texts, one can argue that there might be a trend that only the most recent online publications will be quoted. This is because older publications, in particular from the printed world, "lose" their value in the sense that they may be considered as probably not containing the most recent data, information or arguments in an ongoing discussion.[907]

Given the current trend, we will soon be going to cross a "critical mass boundary where those publications that are not instantly available in full-text will become kind of second-rate in a sense, not because their quality is low, but just because people will prefer the accessibility of things they can get right away" (Odlyzko 2000, 4). Assuming human inertia, it may well be that as soon as the E-literature of a discipline is "sufficiently large and diverse to give scholars the sense they may have enough stuff for their project, they will be tempted not to look elsewhere" (Mueller 2000a, 8). In the longer run, this will be no problem anymore as soon as most of the sources are indeed online. In some disciplines, however, there is a long way to go still and this may lead to blind spots.

However, once all the material is available online, information seeking behaviour may change again, as Odlyzko predicts: "With lower costs of access, a greater fraction of reading is of the superficial browsing variety. (However, that does not mean that there is less deep study, since there is general growth in information processing.) Older material is accessed much more frequently than before." (ibid.)

Another aspect to consider in the context of changing input is related to changes in knowledge representation (further details below 10.4). In a fully hypertexted environment, the written information gathered by the researchers is presented in a different structure. Hence, I expect that the reader is likely to extract the information contained in a different manner, perhaps with a slightly different focus (on hypertext reading, see 6.4.3).

[907] Geser (1996, 10) adds another possible bias triggered by the use of databanks: as they can only contain past solutions to given problems, their use "may stifle innovative problem-solving", they would "increase the operative relevance of accumulated cultural patterns by making them easily available". As an example, Geser names the possibility that reference lists will grow.

To sum up, what the scholar starts with before specifying the proper research question and elaborating the theme is changing. In some respect, it is (a bit) less (what has not been keyworded or put online), in another it is (much) more (full-text search). It is therefore highly likely that the databases with online resources will exercise "a subtle and important influence on the long-term evolution of research in the field" (Bourguignon/ European Mathematical Society 1999, 113).

10.2.3 Impact on choice of topic

While in the previous section I did not discuss the choice of the research topic, but only how it will be treated, we may further ask whether different subjects will be chosen due to the different opportunities to organise scientific work. Do networked researchers do different things (ask different questions, treat different subjects) than those not working in the net? Obviously, in a variety of disciplines, there is the new field of Internet research, i.e. research on the Internet with the set of tools and concepts applied in the particular field (e.g. from the point of view of sociology, ethnography or law). Here, I am instead interested in knowing whether researchers adapt their research topics and questions because of the new opportunities available.

One such mechanism may be the participatory nature of the new medium. In the report "Realizing the Information Future", the authors observe that "(q)ualitative benefits have arisen with changes in the nature of the work being done: broader interaction can change the questions being asked" (NRENAISSANCE Committee et al. 1994, 113). This may trigger interdisciplinarity (cf. 10.2.5) as well as more collaborative work (cf. 10.3.1).

Another reason for changing or "adapting" topics is the structure of the digital information available. Brandtner gives us a telling example from the humanities:

> "If literature science is in a position to revert to manuscripts and autographs, then the focus of research and theory as well as methodology building will shift and reconstitute. (...) Under today's conditions, [providing optimal access to autographs] is only possible with the help of current information technologies. (...) The structure of the searchable categories also defines the topics of literature studies." (1998, 2055f., transl. MN)

The majority of experts included in my survey acknowledged the potential of the Internet to influence the choice of subject (and perhaps also the choice and perception of new/ different methods). While only philosophers hold that the new media not at all influences their choice of topic, in all other fields the opinion was either unanimously in favour of this effect or at least partly in favour. The reasons mentioned were the following: that new horizons are opened up, in particular, with regard to hot issues in related fields; that one is more up-to-date about what is going on in one's own field and what others are currently doing (orientation effect; this may avoid duplication and enhance connectivity of the research, see 10.4.5); that an international (and often comparative[908]) perspective is added ("inbreeding" of ideas is less likely); that the ease with which projects with remote collaborators can be managed may often stand at the root of a decision to actually

[908] Getz (1997, 3) foresees that "(i)n art and drama, digital files may allow comparative studies previously unimaginable."

engage in it (even if it would be possible otherwise); that the Internet enables the establishment of a critical mass of researchers to lay the foundation of a new field[909].

Against this effect, some experts hypothesised that it would rather be the younger (and peripheral[910]) scholars that are influenced by the available information on the Internet while those with more experience and a better personal network are not. Obviously, individual habits and preferences play a role here, too. Furthermore, there is the argument that the choice of the research topic is mainly dependent on previous research done by the same person and comes, as it were, from "within" the research, not from outside impetus. In addition, the policies of research funds, the aims of the respective research institution and money play an important role.

To sum up, the net impact of the Internet could only be marginal in some cases, but there is evidence that ICT has an impact on the choice of subjects in other fields.

10.2.4 Creative potential of the new media

While some fear that the Internet brings chaos and less clarity (too much "background noise" in the words of Glanz 2001), others point exactly at the creative potential for the research process of this very chaos produced by the wealth of information in the network, by the various forms of interactivity and by participation.

Written E-mail discussions are one such half-chaotic medium which may generate ideas (Gresham 1994, 48). "Scholarly skywriting" (see 7.2.4.4) may revolutionise how science is done. Obviously there is "plenty of room on the net for exploring freer possibilities, and the collective, interactive ones, are especially exciting" and an important potential of "unrefereed discussion, perhaps among a closed group of specialists with read/write privileges (while others have read-only privileges)" (1993, 9). Arguably, the shift from P- to E-publishing is not only a change of medium, but a revolution in the way science is done, namely much more interactively: "(s)cholarly inquiry in this new medium will proceed much more quickly, interactively, and globally; and it is likely to become a lot more participatory" (Harnad 1990, 2). E-publishing and E-communication can be compared to the invention of speech, writing and the printing press. All of them may be labelled revolutionary because they "had a qualitative effect on (...) how we expressed our thoughts, so arguably they had an equally dramatic effect on what we thought" (Harnad 1991, 41). Electronic skywriting could be the next revolution inasmuch as it overcomes limitations of written dialogue. The argument is that it matches the necessary speed for real-time dialogue while at the same time allowing for asynchronity.[911]

[909] The example given was that military historians were completely separated from feminist historians, but then the initiative of the web group "Minerva" (<Cyberlink=580>) helped to transgress the sub-critical mass of researchers in the new field which became now the established area of feminist military history.

[910] On peripherality, see 4.3.4.3.

[911] "The two factors mediating the qualitative effects were speed and scale. Speech slowed thought down, but to a rate for which the brain evolved specific organic adaptations. Our average speaking rate is a biological parameter; it is a natural tempo. Hand-writing slowed it down still further, but here the adaptations were strategic and stylistic rather than neurological; in writing, the brain was underutilized. Evidence for this comes from the fact that when the typewriter and the word processor allowed the pace of writing to pick up again, we were quite ready to return to a tempo closer to our natural one for speech. On the other hand, the constraints of the written medium are substantive, and they affect both form and content, as anyone who has tried to use raw

Others criticise this view for being 'cyberplatonistic' because it presupposes a "frictionless medium of thought that can transcend time and space to get at The Truth" (Fuller 1998, 125f.) and finds it in the Internet, but forgets that there are also material conditions of thought. However, the empirical evidence partly supports that skywriting may indeed stand up to the expectations. Despite all shortcomings, this form of communication, contributed to awareness building and information gathering and influenced "the process by which social consensus – knowledge – was produced" (Lewenstein 1995, 141). CMC offers the "opportunity for serendipitous contact" (Harasim/Winkelmans 1990, 397) and makes "a near-immediate audience" available which those actively contributing a presentation to the extended discussion (conference) found "stimulating and motivating, enhancing their creativity and productivity" (ibid., 399). Therefore, the new media simultaneously support two thinking modes: "brainstorming, as ideas encountered online spark immediate responses; and reflection, as transcripts are studied and responses composed prior to uploading" (Harasim/Winkelmans 1990, 401).

The creative potential has to be tamed, though. For instance, one of the main problems of an interdisciplinary discourse is how to get hold of volatile creativity of the group, i.e. the good ideas coming up and being forgotten as the process goes on. E-mail discussion forums with a searchable archive have been proposed as a solution to this problem (Winiwarter 2000, 6), as well as other forms of "collective memory" such as hypertextual card files (Krajewski 1997).[912] While interactive information dissemination and exchange "contribute to a synergistic relationship among the members of the group" (Harasim/Winkelmans 1990, 397), we nevertheless "need to move beyond 'synergy' into organizing and managing the information generated by a synergistic encounter" (ibid., 405).

The answers of my interviewees in this context varied. While the political scientists, biologists, economists and mathematicians were divided amongst themselves and rather sceptical, all others saw at least some creative potential in the information chaos produced by the Internet. While anthropologists, historians and lawyers unanimously acknowledged the big potential, most sceptics pointed at the danger of information overload, which may easily lead to the opposite of creativity. Some doubted that the effect, although certainly present, is really important.

Brainstorming (and reflection) may thus be raised to a new level, awareness of concurring approaches may rise and ideas may more easily influence each other (cf. also Geser 1996, 7). Borrowing Dennett's (1997) metaphor of the gene-like "memes" – ideas

> transcripts of spontaneous speech can attest: What is acceptable and understandable in spoken form is unlikely to be acceptable and understandable in written form, and vice versa. In a sense there are only three communication media as far as our brains are concerned: The nonverbal medium in which we push, pull, mime and gesticulate, and two verbal media – the natural one, consisting of oral speech (and perhaps sign language), and the unnatural one, consisting of written speech. Two features conspire to make writing unnatural; one is the constraint it puts on the speed with which it allows thoughts to be expressed (and hence also on the speed with which they can be formulated), and the other is the constraint it puts on the interactiveness of speaking thinkers – and hence again on the tempo of their interdigitating thoughts, both collaborative and competitive. Oral speech not only matches the natural speed of thought more closely, it also conforms to the natural tempo of interpersonal discourse. In comparison, written dialogue has always been hopelessly slow: the difference between 'real-time' dialogue and off-line correspondence. Hopeless, that is, until the fourth cognitive revolution, which is just about to take place with the advent of 'electronic skywriting'." (Harnad 1991, 42)

[912] <Cyberlink=69>. Another possible technical solution is heralded by a recent version of a sophisticated software which allows structuring a brainstorming activity graphically in the form of shared "mind maps", both collaboratively and remotely (<Cyberlink=727>).

that proliferate from brain to brain just as genes use living organisms to survive –, one could formulate: the ecosystem for memes is improving because its viscosity is enhanced. However, making use of this ecosystem requires new and special skills that not every researcher already masters. My conclusion is that there is a potential, but it still needs to be realised.

10.2.5 Favouring inter- and transdisciplinarity

Another possible methodological consequence of ICT use is that it may lead to de-sealing disciplines in two variants: interdisciplinarity and transdisciplinarity.

First, *interdisciplinary* work may become more likely since it is both easier to get in contact with people interested in the same subject area but looking at the issues from another disciplinary angle and to access the academic knowledge of other fields. One argument in favour of this hypothesis is that we can observe large numbers of issue websites or thematic websites, which attract the attention of people regardless of their disciplinary background. Wildman argues:

> "Yet all the evidence today points to 'net' or 'relatio' knowledge, i.e. knowledge being generated between the disciplines. The World Wide Web with its 'hotlinks' is an excellent example of this. Clearly WWW has enormous implications for [the future university]. As it is a virtual 'relatio' host (...) Here meaning is less facts and figures locked within their respective discipline boxes and more nodes in networks of realtime web interaction. Consequently meaning is not objective, universal and fixed rather it is intrajective, provisional and partial." (1998, 628)

Technological solutions may help to attain the goal of more interdisciplinarity. Hypertext may encourage such flow of thoughts and information "by removing Chinese walls within disciplines, and Berlin walls between them" (Davenport/Cronin 1990, 182). An interface to the E-print archive "that allows rapid identification of papers that provide pedagogic review material or are otherwise likely to be of specific interest to outsiders" (Ginsparg 1996, 6) has been proposed in order to facilitate interdisciplinary research. Access to knowledge bases has to be organised in a way particularly suited for interdisciplinarity (Winiwarter 2000, 15). A one-stop shopping system of scholarly publishing in a discipline has been envisaged which would be interoperable on the basis of the open archive initiative (OAI)[913] and would promote interdisciplinarity by favouring borrowing from one discipline by another (Atkinson 2000, 67). Once the so-called Semantic Web becomes a reality (cf. 2.2.2.1), interdisciplinarity might be facilitated, not through a (not very likely) harmonisation of terminology, but of the meta-code (Hartmann 2001).

Note, however, that this cross-disciplinary exchange is a huge intellectual challenge and full of premises that are not automatically solved through accessible multimedia databases. As Ingraham forcefully argues, all media, including the latest additions of multimedia and hypertext, developed "their own particular ways of creating meaning and of persuading those who interact with them" (2000, 11):

> "These 'rhetorics' are usually well understood by practitioners within these disciplines and in some cases, e.g. film and television studies, also by scholars who have directed their study towards them. However, these 'rhetorics' are not necessarily well understood by other scholars who may wish to use the data represented in such media in the course of constructing arguments in some other discipline."

[913] <Cyberlink=60>.

Furthermore, we should not forget that personal contact, at least in an initial phase of a co-operative and even more so of an interdisciplinary project, is paramount since you need to find a common language first (cf. 4.2.3). Interdisciplinary research needs a good deal of trust which cannot be produced through CMC, but only face-to-face (Winiwarter 2000, 14). There is no evidence that E-mail is directly associated with greater multidisciplinarity of collaborations (Walsh/Maloney 2002). Hence, the technological opportunities will not be sufficient.

That there is no direct relationship between new technological opportunities and interdisciplinarity seems to be also mirrored in what my interviewees answered. Again, the answers were split: the experts of about half of the fields felt that yes, interdisciplinarity will be favoured, those of four disciplines doubted it uniformly and the rest was split. Most of those answering in the positive direction, however, were not convinced that these favouring factors would indeed be strong enough as "practicalities" speak against more interdisciplinarity. Among these adverse factors, the following were most often quoted: how to find a common language and understanding (difficulties of presentation of highly specialised knowledge to non-specialists) and the forceful overall trend towards specialisation (both triggered by content-related considerations and career tactics). Furthermore, individual preferences seem to play an important role whether or not a researcher is inclined to enter into an interdisciplinary co-operation or discourse. Others pointed at the fact that, not at the individual level, but at the level of projects commissioned by the large funds (national and international), both international co-operation and interdisciplinarity is a key asset of any application.

There is a possible second effect besides interdisciplinarity. At the level of communication with the public and the commissioning bodies, I hypothesise a relationship between the increasing communicative and information space and the type of knowledge production, in particular *transdisciplinarity*. Mode 2 knowledge production "is critically dependent upon the emerging computer and telecommunication technologies" (Gibbons et al. 1994, 10) and needs to be supported by the latest that ICT have to offer (ibid., 14). In the longer term, E-publishing may be an "agent to change the boundaries between academic disciplines" (Hitchcock et al. 1996, 9). One of the most important features of the transdisciplinary mode of research is the interaction with (groups of) people outside academia.

As to whether the "academic ivory tower" would get new doors and windows due to ICT (cf. already 6.4.4.3), the answers of the interviewees were rather sceptical except those of the social sciences, which were rather optimistic. All others were divided or rather negative. Most experts noted that, at least so far, the Internet is more about shopping windows than two-way-doors. Nobody seems to expect active involvement of lay persons, but a few observed increased exchange with professional experts outside academia (for instance, asking for opinions or facts, which can be and is done more systematically today via E-mail than previously in face-to-face conversations). With regard to the latter, it has been noted that there are signs that traditional hierarchies are being circumvented through direct contacts with the experts in a business or administrative organisation. However, some effects in the sense of public understanding of science and awareness building seem not unlikely, including journalists. But even this is critically dependent upon better presentation and non-technical language, which is not at all yet standard.

10.3 Effects due to changes in work modes

> "Work patterns have also been affected. Very significantly, collaboration and joint authorship (...) have been greatly influenced by the Internet".
> (Lubanski/Matthew 1998, 9)

The second set of mechanisms how ICT-induced changes in scholarly communication may impact on substance relates to changes in the way researchers work. Work modes indirectly influence the output in a similar way as different methods do: whether you use different tools (methodology) or use the tools differently (work modes), you cannot expect the same result. As regards changes of work modes we may divide the various effects in two groups, those related to ICT-based collaboration (10.3.1) and those related to time (10.3.2).

10.3.1 Collaboration effects

My conclusion in section 4.3.1.1 was that multi-authorship and the increase of distant collaboration is not caused by CMC, but that the latter contributes to and favours the former to a large extent. Therefore, it suggests itself to look at possible consequences on the substance of research due to increased remote collaboration. The statement "Collaborative work leads to different results than non-collaborative work." was acceptable for practically all my interviewees. We need to distinguish between those potential effects which concern (1) all academic collaborations, at least in principle, and those that are related to ICT use (2).

(1) As has been sustained by a large majority of my interviewees, the pure fact of more people being involved in a project changes the type of outcome as compared to the situation of a single researcher with enough time carrying out the same project. The mechanism behind this is that more people contribute and have to agree to the final outcome. I hold that there is no difference in principle between non-textual-oriented and text-producing disciplines: how an experiment is done, which steps are taken in which order etc. is influenced by the number of people involved in the setting-up of the research. The producing of the research report or paper typically involves a number of editing rounds where the text circles among the collaborators. Each member of the group is likely to both try to get his/her message across and into the final paper and to be convinced or to compromise over the course of the project. Hence on the one hand, co-operative papers may be expected to be less "edgy" and *more consensual*, perhaps only representing the lowest common denominator. Seen from this angle, some of the scholarly discussion that normally takes place after the single-authored paper is published is already part of the production process itself. On the other hand, the involvement of more researchers will typically lead to the inclusion of *more perspectives*, the outcome may become richer in the sense that a greater variety of ideas are incorporated. All but the lawyers in the sample of my interviewees agreed to this idea.

This is not to say that co-operative projects will always lead to the effects just described. It may as well be, in general or under particular circumstances, that co-operation may lead to sub-optimal results, exactly because of the need to compromise which

may hinder the formulation of exciting new ideas.[914] In some rather text-oriented disciplines one may argue that co-operation may even be a hindrance to true progress in the field. Collaboration may be successful only under very particular circumstances (perfect match of interests and working style). In general, the difficulty of coordination and consensus development in a diverse group "may make more heterogeneous collaborations less productive" (Walsh/Maloney 2002, 9). However, in both cases, it is likely that increased collaboration affects the outcome. More generally speaking, the hypothesis that collaboration will change outcomes could be challenged on grounds of general observations about co-operation and non-co-operative behaviour in research.

(2) In contrast to the general effects listed just above, there seem to be a number of more ICT-related effects of collaboration:

- ICT allows for larger and more extended collaborations than non-ICT based or local co-operations. For now, the primary importance of computer tools for cyberscience lies "not in machines that will think for scholars but in scholars using such tools to amplify 'collective intelligence', bringing many minds together for more effective collaborative research" (Gresham 1994, 49). E-information services seem to have a power in the creation of new ideas and the digital sharing of ideas seems likely to expand the human potential significantly (Getz 1997, 21). The above described effect that collaboration leads to the inclusion of more perspectives is *reinforced*. One interviewee pointed at the fact that through the Internet more communication is possible (see also 4.3.1.3) and that this may lead to following a particular line of research or argument which would not have been done in the absence of easy communication.
- ICT may allow for more and more efficient editing rounds, in particular, through E-mail exchange and the use of annotation and shared editing tools. The final product (text) may be *more chewed* through, more elaborated as opposed to a cumbersome, non-ICT-based remote co-operation. The obvious counter-argument here is that people would have to be prepared to engage profoundly in these new rounds of revision and refinement, and if they are not, the outcome would not be different than with fewer rounds. In this context, the report "Realizing the Information Future" argues that "(q)ualitative benefits have arisen with changes in the nature of the work being done: broader interaction can change (...) the review accorded to research" (NRENAISSANCE Committee et al. 1994, 113). Hence more review will make the results different and maybe more sound standing. However, my interviewees were rather sceptical as regards this potential effect. Only the experts in history, physics and medicine and to some extent also in law and papyrology agreed to this hypothesis.
- ICT enables remote co-operation across countries and continents almost as if local. In this case, I hypothesise that papers become *more international* if academics from more than one cultural background are involved. It is likely that the Internet contributes to a growing together of different, previously independent intellectual traditions and hence to new solutions (Starbuck 1999, 190).[915] However, also the contrary may be true, namely that the cyberscientists will be confronted with "highly divergent opinions or little paradigmatic consensus within their specific scientific fields" (Geser 1996, 6) and hence with additional difficulties to reach consensus and new solutions.

[914] A further possibility may be that researchers only couple their individual pieces without any deeper relation between the parts. In this case, the value-added is negligible.

[915] See already above in the text at page 229.

- The opportunity of self-publishing may increase the likelihood that *"dissenting" opinions* (within a group of collaborators) will be brought to the attention of others. Hence, the above mentioned consensual drive of standard co-operations may be counteracted.
- If the authors are dispersed and hence CMC is part of the process, the selection of the *type* of CMC will affect the outcomes (Walsh/Roselle 1999, 58). Whether written, asynchronous communication (E-mail) or synchronous video-conferencing is the main type used in a collaborative endeavour may affect the type of collaborative effects according to the significant properties of the medium. One mechanism could be that different social forms are connected by different types of CMC, as Frühwald seems to imply: "The electronically networked world (...) will provoke different communication habits, different social forms, different interests and questions and answers than the eurocentric world of reading citizens." (1998, 306, transl. MN)
- *Substantive fit*: As discussed in 4.3.1.2, collaboration patterns may become more mediated by substantive fit, rather than geographic or personal linkages. It is to be expected that the overall quality of such projects would be (positively) affected because involving people with more specialised skills impacts on the quality and type of the research outcome. In my sample, most experts are expecting that substantive fit will play more role than local contacts for future co-operations.
- Another aspect of the new ICT-based way of doing science is the worldwide *sharing* of knowledge in so-called shared knowledge bases (cf. 4.3.1.2). Subsequent research is based on the wealth of previous knowledge without it being the sole responsibility of the single researcher to gather all this knowledge on his/her own.

Looking at these potentials in a synoptic way, cyber-collaboration seems indeed to have a huge potential to change the substance of research. While on the one hand the impact of collaboration as such (more perspectives included, more consensual output) will be realised more often as co-operation is facilitated in the age of cyberscience, there are, on the other hand, also special effects of the use of the new medium. In particular, it is likely that research becomes even more international and more based on shared knowledge. Furthermore, the initiators of collaborations may have a better chance of finding the right specialist for each sub-task, which is likely to have an impact on the overall outcome. Also the collaborative practice is probably changing (more communication, more rounds of revision and debate), especially in remote collaborations with the effect that the end-result may be more "chewed", more refined.

10.3.2 Time effects

As we have seen at various occasions throughout this study, ICT impacts on timing in research. Time efficiency of the scientists (cf. 4.3.2.1) is increased and publishing as well as quality control are speeded up (cf. 7.2.1 and 8.2.4.1). Changes in the time frame of research may also impact on the outcome of research. The following impact routes are conceivable:

(1) The acceleration of communication may lead to a reduction of the necessary time to finalise projects, hence an *acceleration of the rhythm of research*. In 4.3.2.2, I already mentioned the "projects which never sleep" (because the research task is shifted back and forth through the different time zones). I hypothesise that researchers involved in such highly rhythmic collaborations are in a different mode of thinking than those who get

feedback and complementary pieces only once in a while. Furthermore, to complete more projects on ever tighter schedules may allow scientific discoveries to follow more quickly one after the other (Walsh/Roselle 1999, 67), the development of new knowledge is accelerated (Getz 1997, 3). Also in the case study on cold fusion, CMC "played an important role in the speed with which developments occurred" and "clearly accelerated the speed at which individuals had to respond to new ideas and new information" (Lewenstein 1995, 127, 130).

(2) Furthermore, the new systems of distributing research results, e.g. via E-pre-print archives, means that the distinction between "direct" (personal contact with author), "indirect" (via libraries and mailing lists) and "no" access to the state-of-the-art lapsed. Consequently, all researchers have, in principle, access to the same information at the same time. Hence this new form of communication has the potential of *synchronising* research, however not universally (cf. 4.3.5.4).

(3) If E-publishing is faster (cf. 7.2.1), there is the possibility of a faster turnover of scholarly publications. The publication system could become more *dynamic* with the effect that new results are being published sooner. While this trend to a shorter half-life of academic knowledge certainly does not hold in all fields, it is likely that it may exist at least in some disciplines. The majority of my interviewees expect that the publication system as a whole will become more dynamic. Those rather sceptical come from papyrology, language studies, philosophy and law. Many pointed at somewhat natural boundaries to the speed of the publication system due to the "bottle neck" of quality control (refereeing) and due to the amount of publications which can reasonably be expected to be produced *and* digested by the community of researchers. For some, these boundaries have already been reached.

To sum up, I found that, as CMC has an impact on the speed with which information can be exchanged, this has a threefold potential effect on the outcome of research: via an acceleration of the rhythm of research, via a synchronising effect and by making the publication system more dynamic.

10.4 Effects due to representational changes

The third impact route of new scholarly communication modes on scholarly outcome relates to how scientific knowledge is presented. This has a number of different aspects. On the one hand, there are novel formats which may have anticipatory effects on the process of writing (hypertext: 10.4.1, standardisation: 10.4.2, preliminarity: 10.4.3), on the other hand, the end product has some characteristics which may influence how further research will be built upon (transparency: 10.4.4, connectivity: 10.4.5).

10.4.1 The shadow of the format

> "The ability especially to augment a text's content through implicit and explicit citation has the most far-reaching implications, which users of networks and hypertext must learn to appreciate."
> (Atkinson 1993, 211)

As we have seen, how scholars communicate their research is changing. So far most E-publishing still somehow duplicates what has already been done for centuries in print and uses the Internet as a new distribution mechanism rather than as a new medium. But we can already observe novel formats of representing knowledge (e.g. experiments with hypertext and databases). For the sake of the argument, I shall presume here that in the long run, the digital world will be perceived as a new medium instead of a delivery channel. The question I would like to raise then is whether this development will impact on knowledge and thinking. In other words: When does form impact on substance?

Based on McLuhan's seminal works on general media theory (McLuhan 1962; 1964) and his followers, a number of thinkers started to apply his main ideas in our context ideas. For instance, it has been argued that "the nature of the final product sets the parameters of the preceding stages of research" and hence, knowing what a hypermedia environment instead of a traditional book allows "will have (...) implications for how the object of study is conceived. In particular, we can postulate that a more deterritorialised and multi-layered field of meaning can emerge as the object of study." (Dicks/Mason 1998, 5.8) Obviously, the textual basis of computer conferencing "fosters the reflective and analytical cognitive skills associated with the task of expressing ideas in written form" (Gresham 1994, 48). Similarly, Ingraham (2000) argues that once the academic community has acquired the expertise to use the digital media, this will have significant implications for the way in which scholarly arguments are constructed. Writing about the future of the universities, Dator points at "the fact that what we think we understand about the world is entirely dependent on the models and media we use to perceive and reconstruct the world. (...) exploring the relationship between what we think with and what we think about" (1998, 617). The literature scholar Mueller (2000a, 6) predicts that "the scholar's role may hover in interesting ways between author, editor, and curator". The author may no longer want to be bound by a principle of selection that favours his/her story and "may want the archive to be capacious enough to support other stories" (ibid.). According to Guedon, E-publishing can be compared to making a film out of a novel. He argues that this "generates effects that go well beyond the simple translation of a text into images" (1994, 2). Likewise, moving text from print to a digitised medium "transforms its functionalities, the way we relate to it, and the way it is distributed and received" (ibid.). Therefore, E-publishing brings about "a distinction between the access to information and the way readers relate to it" which leads to the conclusion that, "(a)ccording to our needs, we materialize the electronic information differently and we search it or study it or recycle it in other documents differently." (ibid.)

Probably, hypertexts and hypermedia presentations would make a huge difference. They are not only a novel form of presenting results,[916] but the making of hypertexts may also influence the type of results to put into the "text". Modularity may force the author(s) to concentrate and focus more, to present the linkage and differences to previous research

[916] See already 6.4.1 on the changing character and type of texts.

and value added of present research. Note that the changing medium may have consequences for both writing and reading. The form of the final product may not only influence the author's thinking (reflexive effect), but may also trigger different thinking on the *receiv*ing end, i.e. the reader (forward effect; see 6.4.3). In some fields of mathematics, for instance, the results are visualised and hence illustratively and vividly presented, thus contributing to a more immediate and perhaps deeper understanding.

Although the technological dynamics are likely to influence all functions of scientific communication – "not conceptionally, but much more in the way these functions can be performed in the future" (Kircz/Roosendaal 1996, 4) – it can nevertheless lead to a "new architecture of scientific communication, provided this architecture is accepted by the scientific community" (ibid.). This new architecture is something qualitatively important: "The emerging electronic tools already heavily influence the way scientists think and represent their thinking and research results." (ibid., 7) The form of scientific communication seems to be an important ingredient in the development of science itself with the consequence "that changing representations will indeed induce completely novel science" (Kircz 1998a, 1 and 9).

In particular, the possibility of conveying knowledge via non-text, i.e. multimedia or simulations or virtual reality, bears unheard of new opportunities. The author of the future might be

> "able to simulate the various analog types of perceptions in electronic (binary) form, [while] the reader of the transmitted message can compare his/her own experience of the same sensory experiences, with the interpretation of the originator. (...) (E)lectronic publishing seen this way exten[ds] the capability to preserve the integrity of completely different kinds of information over multiple copies independent of time and place. (...) With the integration of analog information into the communications, analog information which will be the same for author (originator) and reader (consumer), scientific discourse will deepen and change." (ibid., 5)

In a hypermedia environment, academic interpretation can take advantage of different media. For instance, moving images can be more than a complement to the printed word, but can also communicate content in a different way (Dicks/Mason 1998, 3.8). In such an environment, it would, for instance, be possible "to destabilise this assertion of authority of the image by creatively juxtaposing particular video clips with other narratives in the form of printed text, spoken text and other images." (ibid., 3.9) New meanings can emerge if the authors carefully mount different kinds of 'data', represented in different media (ibid., 3.10).

In a nutshell, the shadow[917] of the future (the intended end product) influences the production. Having in mind as the final product, e.g. a (possibly online) database (instead of a thick encyclopaedic volume) or a multimedia hypertext, should influence not only *how* a researcher works, but also *what* s/he works. Thinking in units of information and possible queries as well as of apprehension of multimedia elements is probably different than writing for a more narrative medium.

In addition, there may be research fields in which we would not only have to speak of a pre-effect, but of a complete change of methodology. If hypermedia is used as a new form of knowledge representation one may expect that (data) analysis and presentation happen in the same medium (Dicks/Mason 1998, 5.2). In ethnography, for instance, one can distinguish between the cross-referencing approach to data analysis and the strategy of indexing. The cross-referencing approach avoids de-contextualisation and subsequent

[917] I am indebted to F. W. Scharpf for suggesting to me the notion of "shadow of the format".

re-contextualisation of data which "potentially allows for a more embedded and holistic analytic approach" (ibid., 5.5). A study which compared a traditional book-like approach to ethnography with a novel hypermedia approach suggested "that there may be consequences for how theoretical models are conceived once their graphical representation is no longer confined to a single-medium". This is not to suggest "that there are epistemological consequences per se, since to do so would be to posit a strong form of determinism whereby thought is defined by and confined to the conventions of particular representations." Quite to the opposite, "since the human mind is clearly capable of making multiple linkages and connections, and since the social world itself requires flexible and multi-faceted analysis, then the creative integration of different media may offer the reader and analyst a more adequate approximation of the richness of (...) knowledge." (ibid., 6.5) Also the political scientists Kulchitsky/Lavoie argue that hypertext systems for case study research (2000) may bring about new, previously not possible results.

In some respects, this perspective is not without problems. For instance, the visualisation of results may make recipients credulously believe the results and the methodology (Coy 1999). Computer-based methods would not yet be enough challenged and analysed, which would lead to a creeping devaluation of the discourse about methods. Furthermore, while multimedia elements may improve absorption of the knowledge, it may as well have a negative effect on knowledge production. Multimedia is costly, good multimedia even more so, not only in terms of money to be paid to specialists and for sophisticated software, but also in terms of time spent by the individual researcher designing and arranging the novel publication. The individual researcher might soon be in a position in which s/he feels almost obliged to "enhance" the publication, i.e. to add multimedia, because everyone does it. A similar phenomenon can already be observed in relation to the increasing sophistication of formatting papers before releasing them to the public (cf. 5.4.1). One could argue then, that this might lead to proportionally more time spent on form than on content.

In any case, it seems too early to draw any definitive conclusions on this issue. It seems nevertheless safe to venture the prediction that there will be "not a simple reproduction of a given pattern in a new medium while people get used to that medium" (Hert 1997, 332). As scholars have only started to get acquainted with the new medium, this stage has certainly not been reached yet. This expectation was matched by my interviewees. When presented with the statement "Bearing in mind, in what format academic knowledge will be presented after the research is completed, already influences the production of the knowledge itself."[918], the majority agreed. While only the physicists and mathematicians do not see any direct connection between knowledge presentation and production and not all economists, biologists and anthropologists would agree, all others believe in this pre-effect. However, while there was agreement in principle, it turned out that the interviewees had only limited or no experience with novel publication formats. Hence, their answers were speculative. In particular the experts professionally studying language were certain that focus and presentation determine content. Those from the natural sciences tended to sustain that form does not play an important role anyway and that arguing and persuasion with what ever means is less important and hence what counts is the result proper (the "substance" in my terminology). However, even in the case of biology "illustrative experiments" are known which are only done with a view to producing a picture for the publication although the result is already known.

[918] Question 71, see Annex III.

In conclusion we may say that although there is only very limited evidence yet, my initial hypothesis may hold in the future. It seems very likely that the novel E-publication formats (hypertext, multimedia, database publishing) would lead to anticipatory or pre-effects in the realm of knowledge production. In a trivial sense, this is no news as it certainly "somehow" influences every author whether s/he is writing a short research article for a high-standing journal or rather a chapter in book. This impact mainly relates to form. However, what I tried to show here goes well beyond this trivial meaning and postulates that indeed different substance may be produced if we start writing for a completely new medium.

10.4.2 Standardisation

Another type of pre-effect of the sort of knowledge representation envisaged is standardisation of some aspects of the academic output. How academic results are published is already highly standardised in the world of print. Think of the various types of scholarly writings, of the formal aspects and of the, in some disciplines, rigorous standards relating to the structure of a scientific article. In the digital age, the fact that the documents are shared and stored in electronic format adds a new route for specific standardisation. We may distinguish (1) hypertext, (2) meta-data standardisation and (3) building block standardisation.

(1) As to the option of hypertext instead of linear text (cf. 6.2.3), I discussed scenarios in which it is quite likely that the various hypertexts of a (sub-)discipline would grow together, would be interconnected, thus leading, in the long run, to a sort of knowledge web or knowledge base (cf. 6.3). In these scenarios, the likely consequence seems manifest that "the fact that information can be distributed in identical form and independent of time and place forces strong needs for tools and methods to compare the various aspects of the material, hence drives to standardization" (Kircz 1998a, 3). Such an elaborated structure which subdivides the article into a number of constituent parts such as a section describing the experimental setting, the data, the methodology, the results etc. has already been proposed (Harmsze 2000). Also the links between the modules are standardised and hence articles in this format will be comparable and can be easily connected (cf. 6.2.3.1 and 6.2.3.2).

(2) Meta-data, i.e. machine-readable meta-information about a document, such as name of author, keywords etc., for instance are the subject of intensive standardisation (e.g. Dublin Core[919]). Furthermore, XML, the emerging new (meta-)standard of "tagging", i.e. technically structuring documents for the web (cf. 2.2.2.1), will inevitably lead to standardisation. Only if the relevant documents in a sub-discipline use the same set of XML tags, i.e. the same XML idiom, then the true potential of this powerful new tool can be fully explored. There are already a number of discipline-specific XML dialects, from MathML to the ThML (for theology). Others explore the possibility of structuring written electronic discourse over the net by proposing a discourse mark-up language (DML, Rost 1996b), see 6.2.3.2.

(3) A specific kind of standardisation is likely to emerge in the digital authoring environment where authors have access to their own publication archive. By re-using the

[919] Cf. 2.2.2.1, <Cyberlink=252>.

same formulations or text components on different occasions (in different articles), authors "standardize and routinize verbal expression habits or explicit thought structures" (Geser 1996, 4).

In sum, while the "building block" standardisation is implicit, both the trend towards meta-tagging and mark-up and the possible shift to novel E-publishing formats requires some explicit standardisation. This is not to say that there will be an impact on substance in each and every case. However, the alignment with these standards may have effects on how to structure a text, how to express an argument and what keywords to use. Anticipatory effects on later phases of academic knowledge production are to be expected.

10.4.3 Preliminarity

There is yet another pre-effect of the digital format of academic publications. In contrast to their printed counterparts, E-publications allow, in principle, for constant update.[920] For instance, there may be subsequent versions of the same document and comments or addenda may be directly linked to the original (for a detailed discussion of the fluidity of digital publications, see 6.4.1.3). This possibility in principle may trigger a new culture of what could be called "preliminarity" with both positive and negative effects. On the positive side we may list that feedback and reactions can be taken into account by the author. In contrast to the printed world, an author who was convinced after publication that some of the arguments or data in the paper are erroneous may be given the opportunity to rectify the mistakes. Furthermore, even without initial errors, a paper may become incomplete if not obsolete through subsequent research. In particular authors of articles loaded with up-to-date empirical evidence and of state-of-the-art survey articles (and their readers) may be happy to have the chance to keep it up-to-date. On the negative side, one needs to hold that knowledge stability is potentially in danger. If there is always a chance to rectify and amend a result even after publication, there is less incentive to make the piece "water-tight" in the first place. The WWW can be said to produce intrajective, provisional and partial meaning (Wildman 1998, 628). It may become a habit to publish only interim results and never final results. In addition, if different versions of the same text are in circulation (and quoted), this could easily lead to less clarity and even chaos. Institutionalised mechanism will have to be developed to solve this uncertainty (for instance, allowing it only for working papers, but not for published articles; see 6.4.1.3).

All but a few of my experts interviewed in biology, history, economics and physics believe that there is a tendency towards preliminary publishing, i.e. continuous updating of E-publications. Some not only expected a reinforcement of this trend, but even explicitly approved it, for instance, because it makes transparent the implicit preliminary nature of all research. Unanimously, the desirability of this is disputed. Version control and strict rules for updating are demanded. Those who do not see the future of academic publishing in terms of preliminarity either argue that the scientific community will curb it (i.e. establish restrictive rules) or believe that researchers have an incentive to terminate papers (i.e. not to work on them indefinitely because they want to start new things). In the

[920] This is qualitatively different from "versioning" in the printed world: further edition of books take a long time and slightly revised versions of articles under different names are rather due to the current "publish or perish" culture than to any content-related necessities.

mind of some, continuous updating would not be "serious science". Others see it as a positive incentive and feel a pressure to keep their web sites up-to-date.

I conclude that the novel opportunities of updating publications in the digital world are both a virtue and a vice. The possible negative effects will have to be counter-balanced by the establishment of new rules. However, as all scientific results are intrinsically preliminary, the digital medium also opens up new ways of coping with this transitory nature. It seems likely that this will have an impact on knowledge production itself.

10.4.4 Transparency

Disclosure of data and supporting or non-supporting material may be standard and to some extent also legitimate in particular circumstances, for instance in highly competitive fields (cf. 3.4.3.2) and in fields which are quite close to economic application (cf. 3.4.3.1). However, the main driving force of the overall collaborative endeavour "academic research" is openness and sharing of results – science may be understood as an open source project (DiBona et al. 1999), see 9.1.3.3 (2). Cyberscience may be in a position to further transparency. This has three aspects:[921]

(1) Because of obvious restrictions of "real" space in traditional print media, the empirical data and other sources (the so-called primary information) only rarely form part of the published research results. In many cases, it may however be of great interest to have a direct look at this information as it forms the basis of the research. This could easily be done in an electronic environment through "embedded citing" and "hypertextured documentation". In 6.4.1.4 (1) I have already discussed these perspectives in-depth. A number of voices in the literature sustain this hypothesis (Davenport/Cronin 1990; Kircz/Roosendaal 1996, 8; Burg et al. 2000, 7; St. Laurent 1992). When confronted with the idea that transparency might be enhanced in the digital age, my interviewees' assessments differed according to discipline. I came to the conclusion that, as disclosure of information is also part of the disciplinary culture in some fields and as there is not much experience with E-publishing yet, it may well be that this transparency effect will only occur in the longer run.

(2) Furthermore, transparency vis-à-vis (or: visibility for) the extra-academic world touches upon the wider issue of the relationship between science and the public since the Internet is creating a new interface between these two "worlds" (see also above 10.2.5 on transdisciplinarity). It is not unlikely that scholars are already or will be very soon aware of this new interface. Awareness of another potential public outside the scientific community may change the way the results are presented and worded and may eventually feed back on the type of research being conducted in the first place.

(3) Another argument in this context is related to the idea that the Internet has a potentially "democratising" or innovative effect on science and research. It may be that the more convenient publishing opportunities (easier access to peers) may give greater incentives to non-mainstream scholars to actually pursue their line of research because they have now a bigger chance to gaining publicity than before (when they had to fear that their research would never pass the refereeing gates of the relevant publication outlets).

[921] Geser (1996, 12) points at a fourth aspect (of a slightly different order), namely that "individual producers can make their private intellectual world and creative processes much more transparent by communicating not only 'finished' papers, but any kind of preliminary and transitional drafts or notes."

In all three cases, both a pre-effect for the knowledge production – the authors know that what they are producing is more transparent – and an impact on subsequent research – the readers may get a deeper and more informed understanding of previous (including non-mainstream) research on which to build their own work.

10.4.5 Connectivity/interconnectedness

Closely related to the former issue (transparency) is a possible further consequence of publishing in the digital medium. I define "connectivity" of research as the fact that one piece of research has a good enough "interface" towards the rest of the relevant research, in other words that it fits well and is related to and embedded in the cumulative knowledge of a discipline. In this sense connectivity makes research accessible and useful for related (parallel or subsequent) scholarly work. Connectivity may be enhanced in an electronic environment. Three interrelated effects may be distinguished: First, the quoting of sources becomes easier due to easy access to almost everything written about a subject and hence aggregated footnotes may become widespread. This effect is to be expected the more "additive" or "cumulative" a discipline's way of accumulating knowledge is (cf. 3.4.4.3). Second, having primary and secondary sources at your fingertips instead of having to go to the library and copy or excerpt each and every piece before you can work with it, may enhance the likelihood of quoting more sources. By the same token, this is likely to make your work more embedded in the work of colleagues, in particular by cross-hyper-linking. The results may become more "networked". Third, this may as well lead to fragmentation of knowledge: specialists working in their sub-sub-specialities might become unable to speak to outsiders and hence unable to communicate their knowledge in a "connectable" manner. By the same token, this might further "school" building, i.e. the creation of circles of researchers interested in the same topic, applying the same methodology and tending to quote only members of this circle while ignoring others.

This hypothesis was already the topic of in-depth analysis in 6.4.4.2. There, I also reviewed a number of authors pondering this issue (Kircz 1998a; Kling/Covi 1995; Bainbridge 1999). The majority of my interviewees expected an improvement of the connectivity of knowledge through the Internet. While acknowledging the potential, many interviewees, however, referred to a changed disciplinary culture as a precondition for more connectivity. One element of this change may relate to present time constraints of scholars. The availability of material to which one could connect alone is certainly not enough. As long as publication pressure and day-to-day working circumstance do not allow for more reading time, it may be difficult to realise the potential. I finally come to the conclusion that it is likely that the digital, "hypertextured" publishing and communication environment may, in the long run, lead to more connectivity of research.

10.5 Does ICT influence thinking and analysis?

The short answer to the question in the heading is that it certainly does. I have gathered enough evidence and arguments to sustain a "yes", in principle. The longer answer, however, is less simple. The use of ICT in academia only seldom directly influences thinking and analysis, but does so mainly indirectly by setting general parameters and different incentives, and by changing framework conditions for academic knowledge production. Furthermore, many of the potential effects are not yet visible, but may only appear in the longer run. Note that we have had only very short experience with the new media and they have even changed constantly along the path. For some potential impacts discussed above, it is simply too early to give a final assessment. However, the following summary reveals that I found a considerable number of areas that are, on the one hand, related to thinking and analysis and, on the other hand, exposed to the influence of ICT.

As regards *methodology*-related effects, I found, first, that ICT is opening up new ways of producing results that could not have been produced otherwise. This relates to new ways of accessing data, distributed computing, Internet surveys and time zone shifting of research tasks. None of these ways is universal, but their applicability depends on discipline and research task. Second, the initial input to every research project is definitely changing due to the widespread instantaneous availability of information resources. At least for the phase of transition, I found that selection is an issue here. The wealth of information may lead to overload and the concrete selection may be biased towards availability through the electronic networks (later on sophisticated filters will be available and there will be an ever diminishing share of material not yet online). Third, at least in some research fields, it seems likely that the choice of topic may be co-determined by the availability of up-to-date information in the Internet. Fourth, there is a potential that the chaos produced by the wealth of information in the network, the various forms of interactivity and participation leads to new creativity – but the potential still needs to be realised. Fifth, there seems to be no mono-causal relationship between new technological opportunities and interdisciplinarity, but again some potential to ease interdisciplinary collaboration exists. The technological opportunities are certainly not sufficient. Similarly, genuine transdisciplinarity is not likely to emerge simply because the academic ivory tower has got new shopping windows (the WWW) and easy-to-use communication channels. Without particular efforts, better dissemination and awareness of scientific results, not to speak of an interactive exchange, is not likely.

Beyond methodology, also changes in the research *work modes* have the potential to impact on the substance of research. While, on the one hand, the general impact of collaboration as such will be realised more often as co-operation is facilitated in the age of cyberscience, there are, on the other hand, also special effects of the use of the new medium. Research is likely to become more international, more based on shared knowledge, and the initiators of collaborations may have a better chance to find the right specialist for each sub-task. As collaborative practices are also changing (more communication, more rounds of revision and debate), especially in remote collaborations, I expect effects on the end-result, which may be more "chewed", more refined. Furthermore, I found that as CMC has an impact on the speed with which information can be exchanged, this has a threefold potential effect on the outcome of research: via an acceleration of the rhythm of research, via a synchronising effect and by making the publication system more dynamic.

Finally, a number of potential effects on substance due to changes of *knowledge representation* can be distinguished. First, what I call the "shadow of the format" effect, means that it seems very likely that the novel E-publication formats (hypertext, multimedia, database-publishing) would lead to anticipatory or pre-effects in the realm of knowledge production. Indeed, different substance may be produced if we start writing for a completely new medium. Second, the trend towards meta-tagging and mark-up as well as the shift to novel E-publishing formats requires some standardisation. The alignment with these standards will have effects on how to structure a text, how to express an argument and what keywords to use. Third, as all scientific results are intrinsically preliminary, the digital medium opens up new ways of coping with this transitory nature. It seems likely that this will have an impact on knowledge production itself. Fourth, the transparency-enhancing effect of the new media have both a pre-effect for knowledge production – the authors know that what they are producing is more transparent – and an impact on subsequent research – the readers may get a deeper and more informed understanding of previous (including non-mainstream) research on which to build their own work. Finally, there is a chance that the digital, "hypertextured" publishing and communication environment may, in the long run, lead to more connectivity of research. In other words, the pieces of research substance may have a better "interface" towards the rest of the relevant research and hence contribute to more cumulative knowledge production.

IMPACT ON RESEARCH SUBSTANCE

Methodology
- Outcomes, otherwise impossible
- Initial input side changes
- Impact on choice of topic
- Creative potential of the new media
- Favouring inter- and transdisciplinarity

Work modes
- Collaboration effects
- Time effects

Representation
- The shadow of the format
- Standardisation
- Preliminarity
- Transparency
- Connectivity/ interconnectedness

Overview 10-1: ICT-related impact on research substance

What I have done so far in this chapter (cf. Overview 10-1) is look at potentials and assess their impact in a more or less "neutral" way. I studied change without judging it. The former is an adequate answer to my initial question (namely whether there *is* influence on substance). The latter goes beyond this and is a normative question (cf. 1.2.4.3). Whether research will be "better" or "worse" is indeed a completely different issue and cannot to be answered by our means.[922] For sure, a few of the potential effects discussed above suggest a desirable trend (for instance the enhancement of transparency and connectivity, or the alleged creative potential of the new media). By contrast, the notion of a bias towards information available through the electronic networks or the possible im-

[922] See already 1.2.4 on the notion of impact assessment as evaluation.

pact on the choice of topic will have negative connotations for many observers. And a third group is probably neither "good" nor "bad", whatever the yardstick, but simply different or new (e.g. if outcomes can be produced which would not have been possible before). Beyond this superficial distinction, however, we lack the means to evaluate in-depth the developments at stake. I submit that asking scholars whether they think that, in general, their work has improved due to the Internet (as, for instance, Lubanski/Matthew 1998, 8 did)[923], does not lead to reliable results. Not only does such a general question mix up all the possible effects I have just analysed (that is the level of aggregation is too high), but it also confounds the interviewees' different evaluation standards, experiences and levels of knowledge. Furthermore, it is rather doubtful whether any aggregated yardstick for quality of research can be found at all. Too divergent are the views on this issue. I therefore refrain from using the term "quality" in a normative sense as in "improved quality", but use it in the sense of differences in kind or type. It is up to every reader of this chapter to make normative evaluations for him/herself.

Summing up, it seems impossible at this point in the development of cyberscience to do more than list these first assessments. While a noteworthy potential to impact on the substance of research is certainly there, it awaits to be realised. Final conclusions cannot yet be drawn as there is not enough experience yet. However, even if I cannot come up with a definitive assessment yet, my explorative analysis certainly succeeded in structuring the field of research by pointing at and filtering out those areas and aspects of scholarly activity which are most likely to be affected. Further research should focus on these particular hot spots with more empirically oriented, perhaps even experimental, research designs that can grasp these phenomena adequately (which will become more feasible as time progresses).

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In Part Three of this study, I analysed impact of ICT on academia in a variety of dimensions. Part Four of this study draws conclusions at several levels. The following chapter (11) discusses the implications of cyberscience on science and research policy. The final chapter (12) will draw overall conclusions by pulling together, first, the various scenarios discussed throughout the rest of this study with a view to improving our understanding of the probable future development, and second, the various conclusions of the preceding discussions in order to interpret these findings in the light of my conceptual framework.

[923] He reported that "(i)n terms of quality, 6 of every 10 respondents said the quality of their work had increased due to their use of the Internet, and 4 reported 'no change'. A similar result is recorded for the effect of the Internet on research generally."