The Paperful Office Paradox

David Frohlich, Mark Perry[1]
Personal Systems Laboratory
HP Laboratories Bristol
HPL-94-20
March, 1994

paper, paperless
office, artifact

Developments in information technology are lowering the barriers to the input of paper-based information into computers. However, the consumption and use of paper itself shows no sign of declining. We offer an explanation of this paradox in terms of the functions of paper as a cognitive and social artifact. In particular, we show how paper is used to support cognition as a filter and reminder for information, and to support social interaction as a medium for asynchronous communication. These functions are identified from detailed interviews and observations on the creation of paper through writing, photocopying and printing. The implication of the findings for new office technology are discussed.

Internal Accession Date Only
[1] University of Wales, College of Cardiff

1 The paperful office paradox

Information technology, as the name suggests, has brought about a revolution in the way in which people can perceive, capture, manipulate and distribute information. In particular it allows visible information to be held 'electronically' in digital representations which can be displayed at different sizes and resolutions on computer screens, changed and re-combined easily, stored in very compact formats, retrieved in sophisticated ways by appearance or content, and transferred quickly over large distances.

New developments in information technology are further expanding the ease and scope of things that can be done with visible information. Fast scanners fitted with automatic document feeders now allow paper documents to be input into computers in great volume. Digital cameras and hand scanners allow individual pieces of information to be input with little effort. Document management systems can file away such information and allow its retrieval by both manual and automatic methods. Workflow and groupware systems can route information around an organisation according to clerical procedures or social processes, while electronic mail systems and fax machines allow more ad hoc exchanges of messages between individuals. Finally, pen based computers are beginning to support the direct input, storage and retrieval of handwriting through the writing surface itself.

Despite these trends, paper and not electronics remains the dominant format for visible information in current office work. In fact, contrary to early predictions about the paperless office, computers appear to have led to an increase in the use of paper at work. For example, recent statistics from the Interleaf Corporation (Cambridge, MA) gathered from studies by Xerox, AIIM and the Gartner group show that office paper use went up from 13.7 million tons in 1979 to 22.8 million tons in 1989, and that approximately 92 billion paper documents are produced each year (cited in Dykeman 1992). Furthermore, even the most cursory glance at the 'clutter' of a modern office will confirm the pervasiveness and importance of paper in office work practice. We refer to this situation as the *paperful office paradox*.

In this article we provide an explanation of the paperful office paradox in terms of the functions of paper as an information carrying *artifact*. We show that the choice of paper as an information medium is not always a choice in preference to an electronic alternative but is often the *only* choice or one made *in conjunction* with work done electronically. Our conclusions have widespread implications for the relationship between paper and electronic representations of information and ultimately for the design and interaction of information technology products.

We begin with a brief review of previous work relevant to the paperful office paradox, the statement of a new approach to understanding it, and a report of two separate analyses of paper *creation* based on interview and observational data.

2 Understanding the paradox

Early studies of office work were often carried out with a view to the automatisation of office procedures and tended to concentrate on the flow of information around the 'office' as a kind of information processing entity (c.f. Newman 1979). Set against this tradition there were a number of studies of office *workers* which pointed out the social and negotiated nature of 'procedures' (e.g. Suchman 1983) and the messy and chaotic nature of paper information used in their production (e.g. Malone 1983).

More recent studies in our own laboratory have tended to confirm and refine some of the findings in the latter category; that office workers employ sophisticated 'piling' as well as filing strategies to organise work in progress both within and between individuals, and to remind them of things to be done (Frohlich 1992); that retrieval of personal information is often done visually or on the basis of some cognitive reconstruction of the prior context of use (Walker & Stenton 1991); and that for some classes of workers much visible information can be thrown away once it has done its job of informing and changing the worker (Kidd 1994).

Finally, experimental studies of paper and screen use have consistently pointed out preferences for paper in reading and annotating prose documents (e.g. Dillon 1992). At the same time observational studies of paper use have described the practices of using large displays or arrays of information to record group decisions or structure discussion, quickly changing the orientation and focus of some view of a document, and easily switching ownership of information for further action (e.g. Luff, Heath & Greatbatch 1992, Tang 1991).

This research has been instructive in explaining the value and intransigence of paper in the office in terms of *behaviours* which cannot be supported so well by computer. For example, computers have not generally supported the annotation or piling of electronic documents, the spreading out and re-organisation of information in solitary and group settings, or the leaving-out, lending and borrowing of information which still 'belongs' to particular individuals. Typically such studies have led to recommendations to increase the sophistication of computers in all these areas, so that more and more of the behaviours associated with paper can be performed by manipulating screen representations.

To progress beyond these kind of explanations we suggest that it is necessary to change the question about paper use from *how* to *why*. Rather than study the way in which paper is used today and compare that to the way in which computer screens are used, it may be more fruitful to examine why it is ever used in the first place. This begins to anticipate a time when a kind of tangible electronic paper is available which has most of the properties of paper and more besides. Why would it get created and what would it be used for?

This is exactly the kind of question asked of physical artefacts in general by a number of researchers within the human computer interaction field. For example, Green (1988) has long been concerned with the cognitive implications of 'information artifact' design, Norman (e.g. 1991) has begun to describe the practical and theoretical properties of 'cognitive artefacts', Hutchins and his colleagues have founded the study of 'distributed cognition' in which physical artefacts are seen as part of the mind of a setting (e.g. Hutchins 1991), while Caroll and his colleagues have developed a form of 'artifact analysis' directed at uncovering the psychological claims inherent in the design of devices (e.g. Carroll & Rosson 1992). The

distinguishing characteristic of all these approaches is a concern to uncover the *function* of artefacts in behaviour and the way in which behaviour is affected by changes in the artifact's design.

While some of this work touches on the function of paper as an information artifact, none to our knowledge takes a sufficiently broad view of paper to address the paperful office paradox. Our study is intended to fill this gap and thereby to connect and extend the artifact view within the office paper debate. It does this by examining reasons for the *creation* of paper through writing, printing and photocopying. These appear to be the three main forms of personal paper creation today, excluding the reception or gathering of paper from others.

3 Methods

A wide variety of both analytic and empirical methods have been employed in previous studies of artefacts. These range from anecdotal analyses of cooker control panels (Norman 1988) to detailed ethnographic studies of ship navigation (Hutchins 1989). To borrow a navigational metaphor, in this paper we steer a middle course between observation and interview methods, using interpolation of why people say they create paper with actual instances of them doing so, captured on video. We refer to these methods as in depth and in situ interviews respectively.

3.1 In depth interview

Arranged interviews were conducted with fifteen members of both technical and administrative staff from Hewlett Packard Laboratories Bristol. Subjects were made up of two secretaries, an audio typist, two managers and ten members of the engineering and scientific technical staff. All were highly computer literate. These people were chosen not only for convenience but also because it was felt that they had an exposure and access to present day technology which would make their reasons for paper creation all the more interesting.

The interview lasted about forty minutes and asked a set of 39 questions, from the general to the specific, about paper creation and use. Questions were grouped into sections on general paper use, writing, photocopying and printing. All interviews were audio recorded for later transcription and analysis.

3.2 In situ interview

Paper creation activity was also videotaped in two communal print-rooms on site. People went to these rooms to collect computer printouts from any of four different printers or to use any of three different photocopiers. Whoever came to print or photocopy during random periods of recording was also asked a series of questions about what they were producing and why. These questions were designed to complement the in depth interview questions so that answers could be compared across settings. Twenty people were interviewed about their photocopying activity and 14 people were interviewed about their printing activity using this technique.

3.3 Analysis

he primary analysis was based on the in depth inteview data, with the in situ data being used to confirm, disconfirm or expand its conclusions. This means that the results are mainly qualitative in nature, and broadly suggestive of general patterns of paper creation for this sample of the office population. Obviously larger scale studies are required to validate the findings of the study as a whole. However within these constraints we have tried to be faithful to the strength and representativeness of behaviours reported and observed in the study. To this end we include counts of the number of responses of various kinds, and often present lists of activities in rank order of their occurance.

4 Key findings

4.1 General paper use

About a fifth of paper is said to be 'created' by writing, a quarter by photocopying and the rest by printing. This clearly shows the prominence of the computer in the workplace and the importance of downloading electronic information onto paper. Whilst all subjects said that

they could dispense with paper given suitable alternatives, this move would be unpopular; demonstrating that although paper is not considered indispensable it is seen as having high value.

An examination of what paper is said to be used for suggests that paper is primarily used in interpersonal communication. This was the single largest reason given for paper creation (ten interviewees); double that of the next highest which was for idea generation and thought structuring. Four subjects said that they used paper as an external memory store, three people mentioned using it in planning (e.g. diary and to-do lists), three as a form of long term storage, three in program debugging and two for taking notes in meetings.

Paper is the most popular medium of storage, especially for regularly accessed documents. A large proportion of people kept both electronic and paper versions of personal documents.

When asked to compared the value of paper and electronic media for representing information subjects spoke of the advantages and disadvantages of each. These reasons have been grouped here into contrasting advantages with the number of mentions given in decreasing order:

The advantages of paper were given as transportability, tangibility, ease of annotation and change, its pleasantness to read, its giving information on content, ease of browsing and flicking through it, its intercompatibility, its being not liable to 'crash', it's shareability and familiarity, it is unlikely to be physically lost, we have freedom of entry type (drawing and text together), it allows three-dimensional handling, is easy to compare, the workspace can be organised around it and it is easy to manipulate generally. There are single mentions that people could pick out words quickly, its being robust, having high aesthetic qualities, that the medium does not get in the way of content, its being the ideal medium of presentation, it is accessible, can be filed according to whim and not just program design and that users were in control of it.

The advantages of electronic information over paper were far less in number and related more to document organisation than information within the document itself. The main mentions were that electronically held information kept its value because it could be revised or changed, that it was easier to send and that electronic information had a small footprint. There were lesser mentions of electronic information as tidy and clutter free, files being easy to find and organise, and it being easier to search for words on-line. Deforestation was mentioned, and there were single mentions of its robustness, its not requiring binding, increased feeling of ownership, preference of reading it, being able to preformat it, ease of duplication and remote access to it.

4.2 Writing

The largest contingent of people write to create personal notes, unformed and usually disorganised in appearance. Most of the writing done for others was committed to electronic form later or had to be filled out onto specialised forms. It can therefore be observed that a large proportion of written things require further processing to make sense, especially if they are going to be given to people who do not have the context to help them interpret it.

Subjects also reported writing on existing printed documents in the same way, to take notes or organise ideas. This was often to revise and extend drafts of electronic documents such as reports or programs which would themselves have originated first from written notes or jottings.

Direct written communication tended to be in the form of short informal post-it notes. These were said to be the quickest and most convenient way of leaving a message. This is because they require no time to set up, they are highly visible and demanding of attention, and the handwriting gives clues as to its originator.

After being used, most written materials were reported to be thrown or filed away, with very little of the filed material ever being used again. Writings in bound notebooks appeared to be kept for longer periods of time, probably because they were further processed than jottings,

with printed and photocopied material pasted together (as in a scrapbook) to provide more context for later interpretation.

The picture which emerges is that of writing as a transitory medium in which information is represented to be acted upon quickly or to be transferred to another medium. Keeping written information long term is uncommon because its value decreases with age as the relevant context becomes further and further divorced from what is written.

4.3 Copying

On average, people use the copier about once a day, although this is job specific; secretaries doing three times this and managers only twice weekly. Typically, this copying is from personal computer printouts which are mainly for distribution, or from externally published materials for distribution or personal reference. Very few people photocopied hand-written notes, which implies that on the whole they are not for distribution.

Most people mentioned distributing photocopies and filing was mentioned frequently. Only very rarely are photocopies ever thrown away. A large proportion of people sent photocopied documents through the post. This is a minor paradox in itself given the availability of free fax facilities on-site.

Photocopying was almost always preferred as a method of duplication because it is faster than writing, scanning or printing. There also appears to be a reluctance to deface original documents (those not created by oneself) which may be one reason for creating photocopies. Photocopying is chosen over scanning in particular, largely for reasons of speed and also because the interviewees felt that there is no benefit over copying from scanning.

In fact there are mentions of scanner limitations other than speed, such as reading must be done off a screen. Scanned material also cannot be taken away from a personal computer (PC) to read. Over printers, photocopiers have the added functionality of automatic paper manipulation (collating, stapling, etc.), which also saves time and has a simpler operation.

Very few people have copying delegated to them although all mentioned doing copying for the benefit of others by distribution.

The in situ interviews backed up the in depth interview results in a number of ways. Almost half the interviewees copied from printouts, a third from printed material, two had delegated material and there were single instances of hand-written documents and program listings. The results supported the idea that personally created documents were copied for distribution and that documents created by others were to keep, although a few public documents were copied to distribute. Over half the documents copied were for distribution, the rest were to be read or taken home although one was to be annotated and one filed. The final destinations of those copies not for distribution were mostly to be filed, with single mentions of filing or throwing away according to content, to show to others, and marking or annotation.

Of the documents copied, half had read them (of these, half had created the documents in the first place), a quarter had flicked through them and a quarter had not looked at the document yet. Two thirds of the subjects copied only one document, the rest averaged at three documents each. A quarter of the interviewees did multiple copies, averaging four each, and the average number of copies made was 24 pages, although this was generally much lower, boosted by a few very large batches (mode = 11). The quality required by two thirds was only to be readable, to be good by a sixth and to be excellent by a sixth. A third of the interviewees used no special functions on the copier and most of the rest used the autofeeder; half used some sort of paper manipulation and there were single mentions of collating, stapling and size transformations. The reasons people gave for using the photocopier they were interviewed at were mainly speed based with (in decreasing order) reasons of being the nearest, nearest to the information source (library), it being the quickest, being the nearest with a particular facility, being easy to use, and having the particular facilities required.

4.4 Printing

The printer was used about twice as often as the photocopier, with the same proportions of job specific differences. All the interviewees printed from word processors, two thirds from email and half mentioned printing from spreadsheets, program listings and graphics

packages. Half said that they filed documents once printed; a large proportion said that they destroyed documents in contrast to the photocopier results. In general, printed documents appeared to be mainly documents in progress whereas photocopied documents appeared to be mainly finished documents.

Few printed documents were said to be sent in the post. Those subjects who reported instances of this gave reasons of incompatabile software and formality. Printing was chosen over electronic transfer mainly for reasons of program incompatibility and technical difficulties. Paper was also said to be more noticeable than email: it exists in a very physical sense and must be physically moved out of the way for example, and cannot be ignored at the touch of a button. Paper was also seen as a part of the corporate culture. Even in a computer company such as Hewlett Packard, it appeared that there were common situations in which paper was the *expected* medium for information. In the interviews nobody considered writing or jotting from the screen rather than printing, even for short documents.
Printing for distribution was mentioned less than photocopying for distribution. Printouts therefore appeared to be mainly for personal use. Because more paper is produced by printing than any other method, this paper is either being stored up in individual offices or destroyed once it has been read and annotated.

Typical types of information said *not* to be printed were short email messages, although exceptions were mentioned for cognitively demanding email and documents to be used later or shown to others. Minor mentions were made of on-line information, computer program listings (because of rapid change decreasing the value of paper copies), personal notes and idea fragments.

As before, the in situ interviews backed up the long interview on a number of factors. Over half the print jobs were text based documents from text editors or word processors. The reasons people were printing were given as (in descending order of frequency) to file, to read, to annotate or fill in, to show to someone, to distribute, to take home, to photocopy, and to fax. All but two subjects had read the documents. Only one of these had not created the documents.

Final destinations and uses of the printouts were given as annotating or writing onto them, to read the document (because screen resolution is poor) and to give or show to other people (four mentions each). There were single mentions of filing and to take away. On average people printed eleven pages, mainly single documents. Three people printed more than one with an average of five documents between them. A third printed only one page, a third, under ten pages and the rest between 15 to 70 pages. The quality of printouts was required by four to be readable, three to be reasonable and five to be excellent. Few manipulations were done with the printer, seven doing double sided printing, (the printer default) and one person reduced the document size. Reasons given for using the printer that they were interviewed at were (decreasing order): convenience or closeness, inertia, speed and single mentions of having postscript, duplex, colour, ease of configuring and ability to print onto slides.

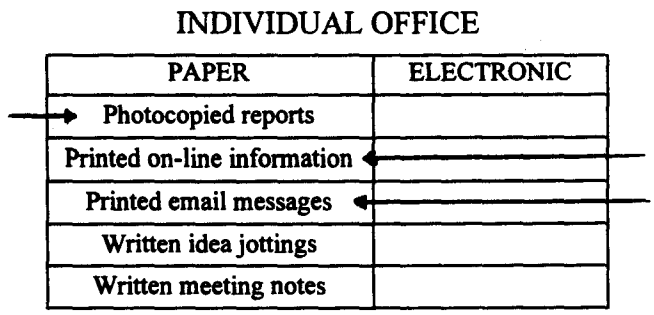
5 Discussion

Taken together, the results suggest that paper has three main functions.

First, paper acts as a **filter** for information. In this respect people create paper in order to extract what is important to them from all the information which is available from various sources. In fact each of the three kinds of paper creation examined here appear to act as filters for different sources of information. Handwriting appears to act as a filter for personal thoughts and verbal exchanges resulting in artifacts like private jottings and meeting notes. Printing acts as a filter for electronic information resulting in printouts of on-line information, important email messages and so on. Photocopying acts as a filter for existing printed information resulting in key newspaper or magazine articles and corporate reports. All the resulting objects can be said to be cognitive artifacts since they function as aids for the mind, mainly by 'attuning' people to relevant aspects of their environment (c.f. Gibson 1979).

The effect of these practices is shown in Figure 1. By turning unspoken, verbal and electronic information into paper and never transferring paper material into electronic form, people effectively move all salient information for any task into the paper medium for further use.

Figure 1. Creation of paper as a filter for information.

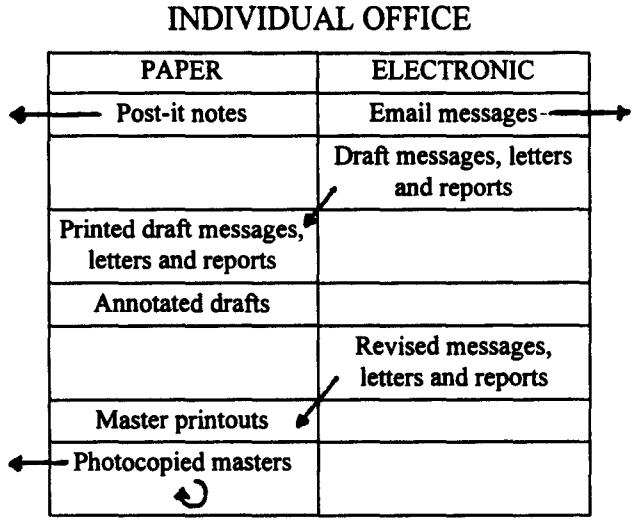


Second, paper appears to act as a **communication medium**. In this role it is used to carry information from one person to another. Indeed this was said by subjects to be its primary function. Again there appears to be specialisation of function by the method of paper creation. Writing is used to carry short informal pieces of information to individuals, often on purpose made 'post-it' sheets or forms. Printing is used to carry longer messages to individuals or small groups, for example in letters and memos, which clarify spoken discussions or set out personal positions in the kind of detail which is difficult to convey by word of mouth. Photocopying is used to carry more extensive monologues to larger groups, in 'report' form, in which some argument is developed at length. All these kinds of objects are social rather than cognitive artifacts since they function as aids to a relationship between individuals, mainly by sustaining interaction during periods when those parties are not co-present.

The effect of this kind of paper use is shown in Figure 2. This reflects a recurrent finding of the study that the production of personal printed communication often begins with reference to all the cognitive artifacts shown in Figure 1, and leads to several iterations of printing out, annotation and revision before a final version is printed and photocopied for distribution. Although this process involves the repeated movement of information between the paper and

electronic media, most transfer of information from paper to electronics is by manual creation (e.g. typing) whereas all transfer in the other direction is automatic (e.g. printing)

Figure 2. Creation of paper as a communication medium



A third and final function of paper is to act as a **reminder** of information. In many ways, this function is derivative from the other two; being the way paper originally created as a filter or communication comes to act for an individual over time. It either bridges the common but shorter delay between collecting relevant information (in Figure 1) and making something of it (in Figure 2), or it connects the less common and longer delay between creating some communication (in Figure 2) and retreiving a copy of it for use in some new task (in Figure 1 again). In the first case people seem to actively filter information to remind them of relevant context over the short term. In the second case people seem to passively hold on to information in case they need to be reminded of its content over the longer term. In both cases the objects created come to function as cognitive artifacts, mainly by re-attuning individuals to things previously known or noticed.

Given this model of paper use we can now offer an explanation of the paperful office paradox. When people are working with information they primarily act to filter the salient parts of it onto paper or to construct paper communications with others, albeit via the electronic medium.

At present, paper appears to be preferred over electronic representations for a variety of reasons. Some practical reasons are that it is easily transportable between people with different office technology, that it can be written on, and that it cannot 'crash'. More psychological reasons appear to be that it is tangible and easily manipulated, pleasent to read, and provides a variety of clues to its content. Finally, there are social reasons which relate to the contractual nature of signed documents and to the expectations of others about the use of paper as the universal information medium.

When people have finished working with information they throw very little of it away. What is disposed of tends to be written information and draft printed material, leaving finished printed material, photocopied papers and key writings to be archived in filing cabinets. All final electronic copies of documents are also kept for the future. The final products of office work are usually printed communications which are photocopied and distributed to a number of individuals in other offices who will use and then archive the material in the same way.

This leads to a situation in which the horizontal and vertical surfaces of the office become filled with a mixture of personally created and externally created papers representing work in progress. In contrast, the closed containers end up with mainly printed material from other people, because much of the personally created material can be thrown away at the end of current tasks, and the rate of reception of material from others is greater than the rate of creation of material by oneself. Parallel electronic copies of finished documents are almost always kept by the original authors in personal information filestores.

Both paper and electronic stores become relatively inaccessible and useless over time because they are constantly growing in volume and are becoming less intelligible with increasing distance from the original context of creation or use.

6 Implications

Although our study confirms the current preference for paper over electronic representations of information, it also underscores the fact that *both* forms are used together at different

stages of filtering, communicating and reminding oneself of information. Furthermore, in some cases a preference for paper is expressed where there is really no available electronic alternative which will support the kind of information activity required, such as spreading information out or placing it in some particular office location. This leads us to make two recommendations for new information technology.

First, better computer-based *alternatives* to paper should be developed to expand the real choice available to office workers. For example, facilities for the review and annotation of draft electronic material would cut down the evident use of printing and writing in Figure 2, and allow information to remain in the electronic medium during the process of its composition. This would begin to save much of the draft printed material which appears to make up the majority of personal paper creation. Better facilities for the electronic distribution of information would also cut down the large amount of photocopying which is done today. Clearly there are too many incompatibility problems between users of different software packages to make direct transmission a feasible option for most people, and there must be problems with the quality and reliability of faxed documents which cause people to use the mail instead.

However, there is a danger here that electronic distribution would only delay movement of communication material into paper form, causing the recipient rather than the sender to perform the printout operation. A lasting impact would only result from also improving facilities for the filtering and reminding of information during work in progress (see again Figure 1). Large screen technology is clearly of relevance here, together with other kinds of technology for the construction and re-construction of 'context' (e.g. Whittaker, Hyland & Wiley 1994).

Second, better support should be provided for the *movement* of information between different paper and electronic media and devices, so that both formats can be used at different stages of office work. In a curious way, this strategy would also add to the choice available to people when manipulating information, since they could feel confident that a decision to go electronic at one point in time would not rule out the possibility of reversing it later, or

indeed of transferring it to another electronic device. This is an issue we are actively addressing in our own laboratory, by developing standards for serial infrared communication between information appliances, including scanners and printers (c.f. Fitzgerald 1993). In general, this is part of larger attempt to design technology which acknowledges the many *functions* to which information artefacts can be put and so support the *process* of informing performed by people and artefacts together (see again Kidd 1994).

Given *both* the above developments of better electronic alternatives to paper and easier movement of information between the paper and electronic worlds we would begin to see precisely which aspects of paper are irreplaceable. Our guess from the current study is that paper would still be used for the *placement* of information around the environment and as a social *token* signifying ownership and responsibility for work itself.

Acknowledgements

Thanks to Steve Payne for critical input to the project.

References

Carroll J.M. & Rosson M.B. (1992) Getting around the task-artifact cycle: How to make claims and design by scenario. *ACM Transactions on Information Systems, 10*, pp 181-212.

Dillon A. (1992) Reading from paper versus screens: A critical review of the empirical literature. *Ergonomics, 35*, pp1297-1326.

Dykeman J.B. (1992) Document management software: Make sure what you get is what you need. *Modern Office Technology, April 1992*, pp37-40.

Fitzgerald M. HP builds in infrared. *(1993) Computerworld*, May 10th 1993.

Frohlich D.M. *(1992) A survey of office work practice.* Hewlett Packard Laboratories Bristol Technical Report, Number HPL-92-121.

Gibson J.J. *(1979) The ecological approach to visual perception.* Boston: Houghton-Mifflin,

Green T.R.G. (1988) Cognitive dimensions of notations. In A.Sutcliffe & L. Macaulay (Eds.) *People and Computers V.* Cambridge: Cambridge University Press.

Hutchins E. (1989) The technology of team navigation. In J. Galegher, R Kraut & C. Egido (Eds.) *Intellectual teamwork: Social and technical bases of cooperative work,* 1989. Hillsdale NJ: Lawrence Erlbaum Associates.

Hutchins E. (1991) The social organisation of distributed cognition. In L. Resnick & J. Levine (Eds.) *Perspectives on socially shared cognition.* Washington D.C.: APA Press

Kidd A. (1993) The marks are on the knowledge worker. *CHI '94.*

Luff P, Heath C. & Greatbatch D. (1992) Tasks-in-interaction: Paper and screen based documentation in collaborative activity. *Proceedings of CSCW '92,* pp163-170.

Malone T.W. (1983) How do people organise their desks? Implications for the design of office information systems. ACM Transactions on Office Information Systems 1, pp99-112.

Newman W. (1979) Office models and office systems design. *Proceedings of the Workshop on Integrated Office Systems.*

Norman, D.A. (1988) *The Psychology of Everyday Things.* New York: Basic Books.

Norman, D.A. (1991) Cognitive artifacts. In J. M. Carroll (Ed.) *Designing Interaction: Psychology at the human-computer interface,* 1991. Cambridge: Cambridge University Press.

Suchman L. (1983) Office procedures as practical action: Models of work and system design. *ACM Transactions on Office Information Systems, 1*, pp320-328.

Tang J.C. (1991) Findings from observational studies of collaborative work. International Journal of Man-Machine Studies, 34, 143-160.

Walker M.A. & Stenton P. (1991) A personal information management survey. Hewlett Packard Laboratories Bristol Technical Report, Number ???.

Whittaker S., Hyland P. & Wiley M. (1993) Filochat: Handwritten notes provide access to recorded conversations. *CHI '94*.