Design and evaluation of the CHILI system

Though this be madness, yet there is method in 't.

William Shakespeare, Hamlet (II, ii, 206)

Abstract

The CHILI system is a general-purpose radiology workstation with teleradiology and telecardiology functions.

The design of the CHILI user interface is made with the purpose to achieve high usability. Usability is treated as part of the product development process instead of being a separate activity.

A number of design principles – rationale – guided the design of the user interface. The minimalism of the system comes primarily from the approach to focus on work tasks instead of functionality. This is accomplished by displaying as much information as possible in one single window. No functions are out of sight in menus or dialogue windows.

An evaluation using questionnaires was performed to assess the usability of the system. The questionnaires include a validated usability measure (the System Usability Scale) to give a global assessment of system usability. Five experienced users were interviewed individually to complement the questionnaire data.

The design approach used in the CHILI system was found to be working, both from an experienced and new user's perspective. The strong sides of the system are the ease of use, the minimalism of the design, and the way the system is adapted to the working environment. Areas where it is possible to improve are the on-line help system, questions regarding available functionality, and user training. Continuous redesign and development has helped increase usability.

Keywords

Usability, Telemedicine, Teleradiology, Human-Computer Interaction, User Interface, Design, Evaluation, Rationale, Questionnaire, SUS.

Telemedicine

Telemedicine is a combination of telecommunication, medicine, and informatics. The prefix, *tele*, implies distance.

Telemedicine as practice is often defined as the use of telecommunications and information technologies for the provision of clinical care to individuals at a distance, and transmission of information to provide that care [32]. By this definition, both the physician and the patient are users of telemedical technology. Telemedicine can, for example, be used for education, decision making, remote sensing, and collaborative arrangements for the real-time management of patients at a distance.

Figure 1. The photo to the left shows the Uppsala University Hospital's image (film) archive, consisting of several kilometers of shelf storage. The archive is, more or less, staffed 24 hours all days. The right side photo shows the hospital's new digital picture archive with equal or higher capacity.

The goals in general are to improve patient care, maximize limited resources, and realize cost savings. Experience show that teleradiology systems reduce film costs, patient transports and travels of the radiologists [2]. There are also environmental gains, as film processing can be done digitally without chemicals.

The quality of health care is improved through faster and better diagnosis as (remote) experts can be consulted for complicated cases. Another advantage is the reduction of costs through resource sharing of expensive equipment and radiologists, e.g. during night shifts.

History

Many medical professionals have tried to provide expertise at a distance. Wilhelm Einthoven, inventor of the electrocardiogram and Nobel Prize winner in 1924, transmitted basic electrocardiograms from a hospital to his laboratory via telephone cable as early as in 1905 [8]. Since then the phone has been one of the most used tools in telemedicine, and still remains so.

Figure 2. Radio News magazine from 1924 showing a patient in front of a radio, suggesting physical examinations soon could be done over the radio.

The shipping trade was an early user (around the 1920s) of telemedical services. The sailor’s profession was not always a safe one and accidents happened, sometimes far out at sea [44]. In situations like this, emergency advice was called upon using radio.

In the 50s, US hospitals experimented with TV broadcast technology to share x-ray images. Closed-circuit television solutions were also tried at the same time period, in and between nearby hospitals [1].

More current technology in telemedicine stem from NASA's efforts in the early 60s with manned space flights [45]. Data from orbiting astronauts was sent to medical personnel at the NASA Johnson Space Center. Biomedical parameters transmitted included astronaut's heart rate, temperature, and ECG.

Teleradiology

Teleradiology is the electronic transmission of radiological images for the purposes of interpretation and consultation. According to Kodak's frequently asked questions on Teleradiology [20]:

> *Teleradiology is the process of sending radiologic images from one point to another through digital, computer-assisted transmission, typically over standard telephone lines, wide area network (WAN), or over a local area network (LAN). Through teleradiology, images can be sent to another part of the hospital, or around the world.*

Radiological images need to be encoded in very specialized ways in order to preserve all information that the image capturing modality provides. To preserve information is particularly important in health care as images are transmitted to remote locations and used as one of the most important sources for diagnosis. For example, since it is imperative to, at all times, be sure an image is associated with the correct patient, the image data itself contains references to when the images was captured, and at what hospital. The image data may also contain the patient name or id. The most common medical image-related standards are ACR/NEMA [29] and DICOM [7].

Because of the many above requirements on images (plus data security, data consistency and integrity etc [38, 5]), commercial products for general computer-supported cooperative work, CSCW, are not suitable options for teleradiology. The application responsible for the transmission and the displaying of the images needs to be specifically developed for the medical domain.

Figure 3. The photos demonstrate an on-line conference, where a leading cancer expert is giving advice to a remote site. Both sides share the same view of the image data on the computer and communicate using a standard hands free telephone.

Teleradiology is one of the leading applications of telemedicine. This technology plays an important role in improving quality of care, including providing access to rural and remote areas. It can also help contain the rising cost of health care.

Usage scenarios

Teleradiology originally started as a remote application (to share radiology resources at a distance – images, equipment or computer systems), but with today's network penetration there is little or no difference between local use inside the hospital and the usage outside – for example, from remote clinics or homes of medical staff or patients. The common access to broadband networks makes the *tele* aspect less prominent today. Almost all modern systems are implemented as (tele-) communicating systems.

Some of the initial usage scenarios included some sort of convenience for the on-call radiologist, or the remote consulting physician that seeks a second opinion (see *Figure 3*). Today teleradiology applications are used inside as well as outside the hospital. They are routinely used for accessing patient data and images on central storage areas. Many hospitals have altogether abandoned the use of traditional film, and digital images are the only images produced.

The CHILI system

The CHILI [9] system is a general-purpose radiology workstation with teleradiology and telecardiology functions. Its main characteristics is (1) the ability to transfer images between users of the application, (2) the on-line viewing and processing of images, and (3) the retrieval of images from external image sources. One of the most important purposes of the application is to (4) enable the sharing of expensive resources, such as high quality film printers, rapid image transportation and image analysis specialists.

Origin

CHILI has its roots in MEDICUS – a teleradiology system developed in the mid 90s at the Deutsches Krebsforschungszentrum (German Cancer Research Center) in Heidelberg, Germany. The MEDICUS system was commissioned to work on ISDN lines, at that time the common way to get fast Internet access. The MEDICUS application was intended for teleconferencing and computer-supported cooperative work (CSCW) in the medical domain.

Functionality

Today, the CHILI system is used for the following tasks:

- Image and report delivery
- Interdisciplinary teleconferences
- Radiation therapy planning

- Quality assurance measures

The CHILI system is well-integrated [13] into the hospital environment using the Digital Imaging and Communication in Medicine (DICOM) protocol [29]. New networking methods, for instance, based on DICOM MIME (i.e. email) are recent additions to widen communication possibilities between new partners, such as small hospitals and doctor's practices [7].

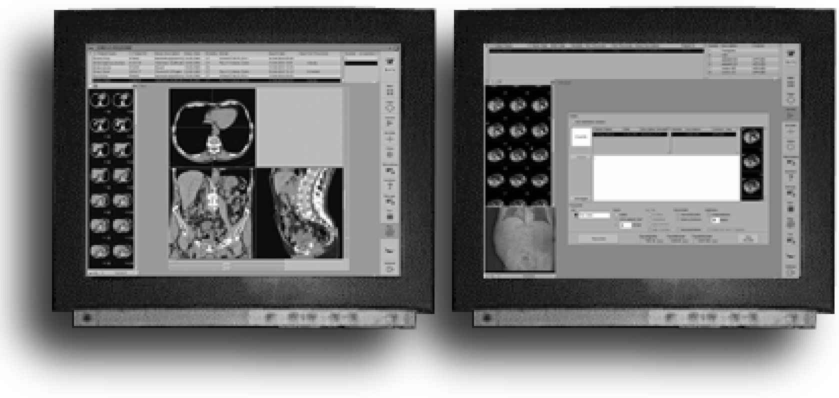

Figure 4. The image shows the CHILI workstation's user interface in dual monitor setup.

Design of the User Interface

The main objective behind the design of the user interface was, already from the very start, to make the system a tool especially designed for medical work as opposed to a general computer application. This emphasis and focus on the *medical work content* lead to a number of design decisions that make the handling different from many standard computer applications.

Usability

It is rare that computer support this actively address usability aspects. We believe this is important to mention as good usability never happens by chance [33].

The design of the CHILI user interface is based on an assurance on usability. Usability is seen as part of the product development process instead of being a separate activity. Lif has shown that the process view is essential for usability [24]. The method of an early and continuous focus on users, empirical evaluation, iterative design and multidisciplinary design teams is sometimes called *User Centered design* (UCD) [10] or *Participatory Design* (PD) [36, 40]. This is, for the major part, the design process used in the CHILI development.

The UCD[1] process differs from other approaches to usability. *Usability engineering* [31] for example, treats usability of a product quantitatively, and attempts to specify objective measures of interaction by model definitions of system, user, and interfaces. When the product is finished it can be verified that it does or does not reach the specified levels of usability.

There is also the view of *usability as a product attribute* [17]. This is a concept influenced by the standardization activities that many (especially medical) computer systems undergo. In this approach one lists system properties or qualities that influence usability, and relate them to objective (in a broad meaning) references. International standards are the most important references, such as the ISO 9241 [14], but usability style guides of software manufacturers can also provide detailed instructions for user interface development and function as objective reference [41]. In addition, there are more general lists of usability principles [4, 15]. These introduce wanted properties of interfaces on a general level.

By UCD we want to make systems design more participatory and self-ruled, by forming multi-disciplinary project teams. The method involves prototypes as a hands-on way for users to express what is needed from a computer system. Prototypes provide a common language for developers and users; a way to iteratively try out solutions. For a more recent attempt to precisely define UCSD see Gulliksen et al [47].

Background design knowledge

Parts of the background of the decision to concentrate on work content originate from a prior research project, Helios, within the framework of the AIM (Advanced Informatics in Medicine) program of the CEC (Commission of the European Communities). The aim of the Helios project was to alleviate the development of medical applications by establishing a software engineering framework especially dedicated to the medical world. During three years of research and development in Helios a team responsible for HCI-matters analyzed work activities, information utilization and user expectations. The team witnessed inefficient user interfaces, and saw examples of computer systems where up to 80% of the working time was spent managing the interface. From an analysis in Helios [32]:

> *In a work situation, where computerized information systems are used, e.g. health care, the purpose of the work performed by the professionals is never*

[1] Also called User Centered Systems Design (UCSD). I make no difference between these two names. For a discussion on the possible differences between UCD and UCSD see Göransson [46].

to operate the computer. The computer is only a tool that will be used and appreciated as long as it efficiently supports the purpose of the work, e.g. to provide good health care for a patient. This means that the interface must be designed on the basis of optimization of the work activities as such instead of just optimizing the use of the computer. The practical consequence of this is that the design must be based on an analysis of how information is being used in the actual work context for which the application (or artifact) is intended. The design must be made so that the management of the interface can be as automated as possible - then the user can make optimal use of his or her creative and problem solving abilities to perform the essence of the work. In this way the computer system will be `transparent' and the user can concentrate on the work activities. We say that the interface must be obvious to the user.

Rationale

A number of design principles – rationale – guided the design of the CHILI user interface.

The aim is to maximize the usability, not the functionality. The approach to focus on work tasks instead of functionality leads to a minimalism in design. This is accomplished by, simultaneously, displaying as much information as possible for each work task.

Making the application work task-oriented is not a new idea. The first ever desktop metaphor, the Xerox Star, was an example of this approach [16]. Later variants of the Star interface made the work task connection more evident; this can be seen in Card’s multiple virtual workspaces of the Rooms Design [6, 11, 22]. The reasons behind a rooms or work task metaphor are several; the arguments made by Card & Henderson targeted problems with limited screen size, navigation, task switching, information access, and interaction. All these listed problems are possible to – at least to some extent – work out with a work task centered approach.

There were many rationale and goals that guided the design process. Below follows the most important goals.

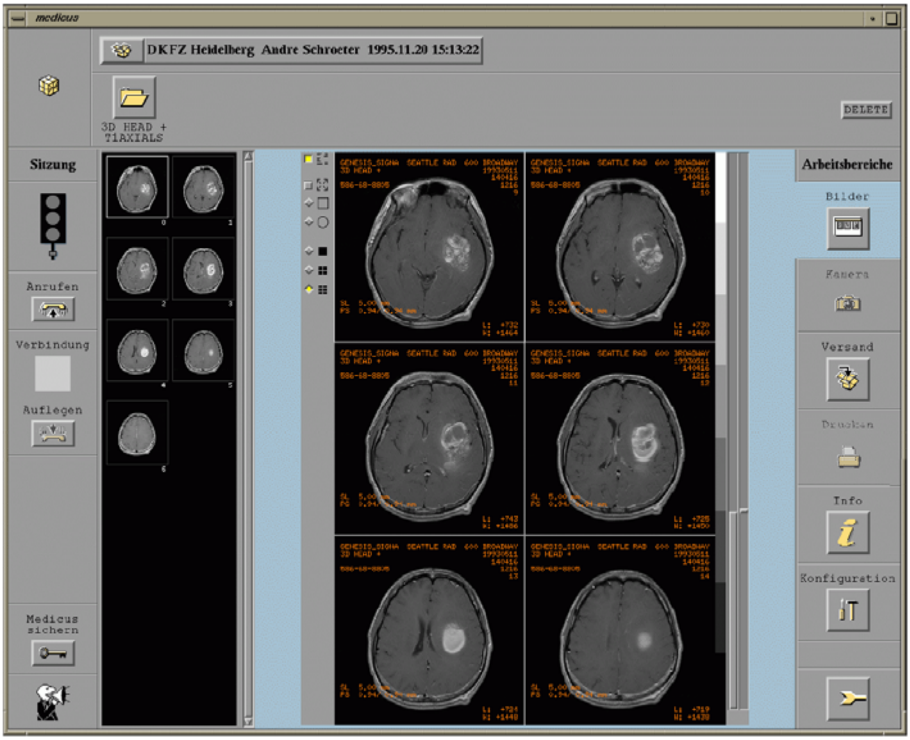

Figure 5. A screen shot of an early functioning version of the MEDICUS system. The prototype shows the “image viewing task” where all functions needed for image viewing and manipulation is present in one single layout.

Single Window

To reduce unnecessary maneuvering and handling of the application itself, all functionality is kept in one single full-size window. There are no dialogue windows, and very few pull-down menus. The traditional menu bar is absent. *Figure 5* demonstrates how all functionality is fitted into one single window.

The reduced screen space available (only one full-size screen) forces the design to be minimal but also complete – all needed functionality for each work task has to be present and clearly visible in this single window. With a design goal of a single window it is not allowable to add yet another function in a new pop-up window or tab pane.

The rationale behind the single window goal is the conviction that the system will be easier to use if the user does not need to move windows around and, in reality, handle the design herself. At the same time all functions will be clearly visible since they are not hidden deep in a menu structure or obscured by a dialogue window on top.

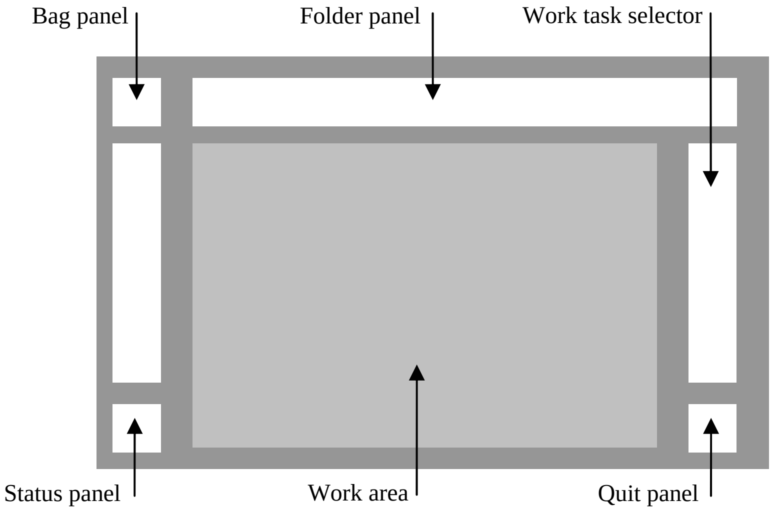

Figure 6. One of the first design drafts of the MEDICUS system, from February 1995. All areas marked white in the figure are static and are always visible. Only the content in the central Work Area will change. Note that no menus are present in the design.

Low cognitive user load

In order to allow the user to focus on the (medical) work at hand, handling of the application itself must be kept at a minimum. Navigation and control of the computer should be as transparent as possible.

To remove the window handling as described above is one such step. Another step is to aim for parallel display of information, so that all data is available exactly when needed; as much relevant information as possible should be visible to the user at all times. This means crucial information cannot be “just one click” away, because one click away means the user still has to let go searching to find that information. This search, no matter how minuscule or fast, interrupts the work process and reduces concentration. A massive, parallel display of information is always faster and easier to use [27].

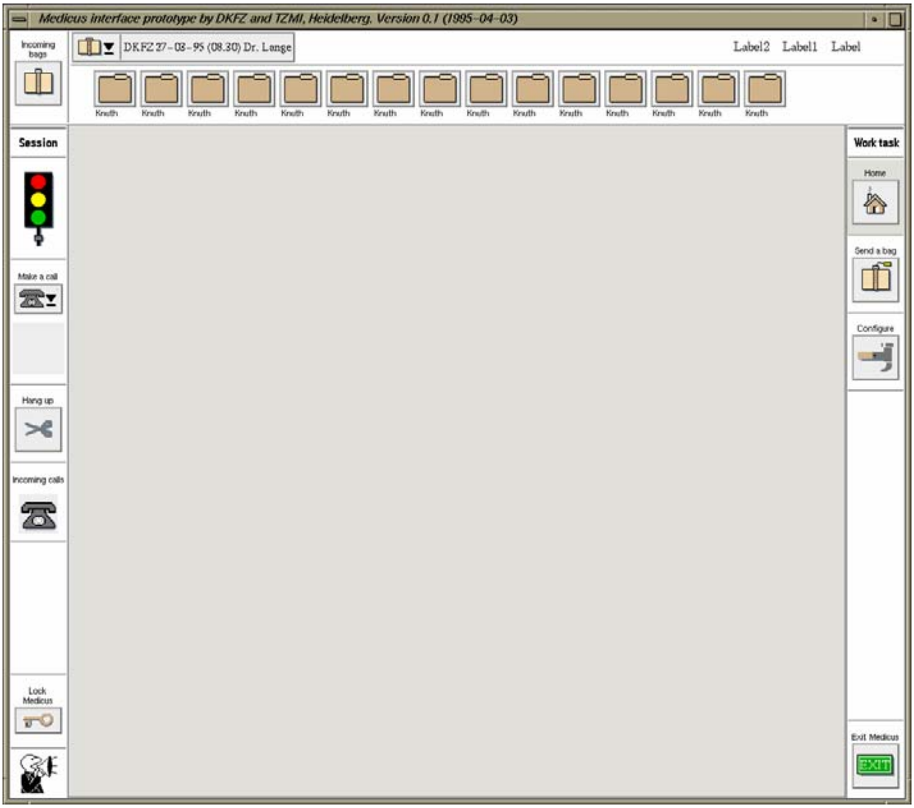

Figure 7. The image shows a basic MEDICUS design draft, with plenty of metaphors such as traffic lights (on the left), folders (top horizontal), and tools (right). The traffic light displays who has control of a shared pointer in a conference session. The folders contain patient data, mostly images.

No training

The system should be easy enough to use so that no or very little training is required. As a consequence of this the functionality must be kept to a minimum so that only the necessary tools need to be considered at design time. The design goal here is to:

Provide the functions needed, no less, no more.

This allows us to stay away from the traditional pull down menus completely, as seen in *Figure 6*. Menus introduce states or mode-dependent behavior in an application which are difficult to visualize in a clear manner, and to get a proper understanding of as a user.

For example, it is quite common that functionality in menus change when using an application. For example, the "save" button in the menu bar is often disabled (grayed out, not possible to select) when no changes have been made to a document. When a change has been made, the save button is again enabled. In this example the enabled and disabled state of the button can help a user understand the state the application is in. However, more importantly, the change from disabled to enabled state happens *inside* the menu, which is not visible. The user is not notified about changes that happen.

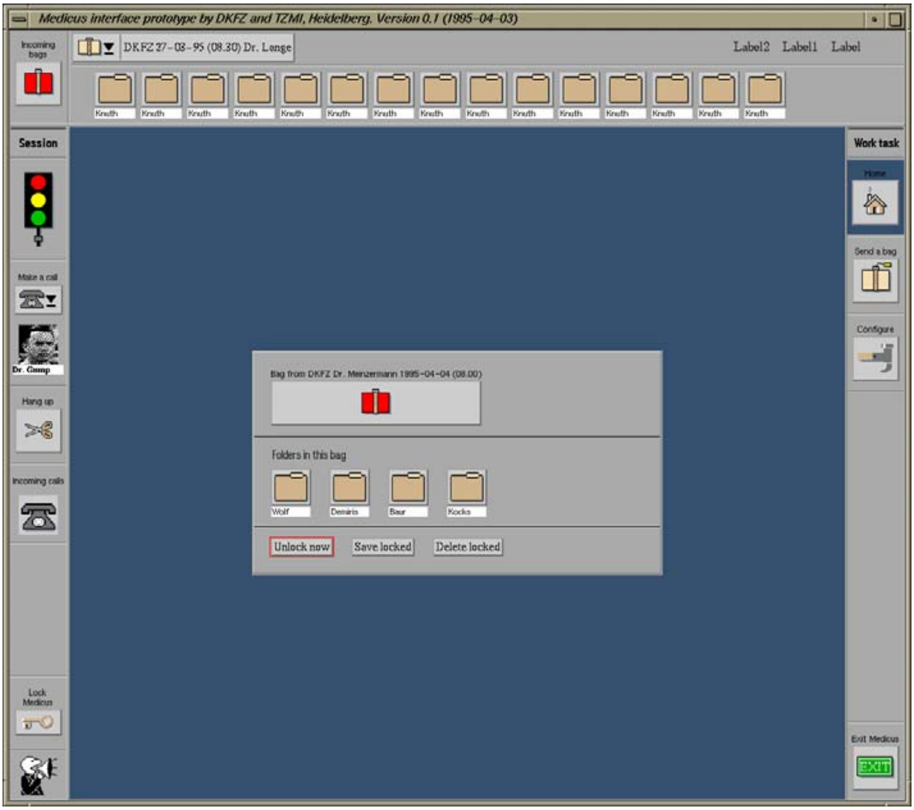

Figure 8. The image shows a late design prototype of MEDICUS.

Focus on important aspects

For a professional user in radiology, the space available for images is the most important criteria. Image size alone is the single most important factor for a successful application in this field. The users have high demands on their working conditions, and the importance of image size is emphasized at all user levels. This and more general requirements for image processing were examined in a separate study [3].

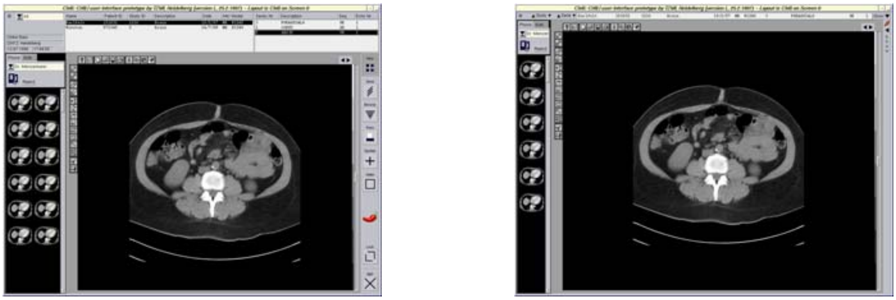

Figure 9. On the left, the application is in the normal mode with full view of all navigation areas. On the right, the database area is shrunk to on line, the lightbox to the left is one image thumbnail wide, and the work task selector on the right is folded. The area for images on the left is 70/30, on the right it is 85/15.

In order to enable a large image area the concept of folded areas provided a solution. This is a technique that allows a user to hide away (to fold) some part of the user interface. These hidden areas are then accessible by some other technique, for example keyboard short-cuts or context-sensitive (pop-up) menus. The folded area may later be unfolded to its original size. See *Figure 9*.

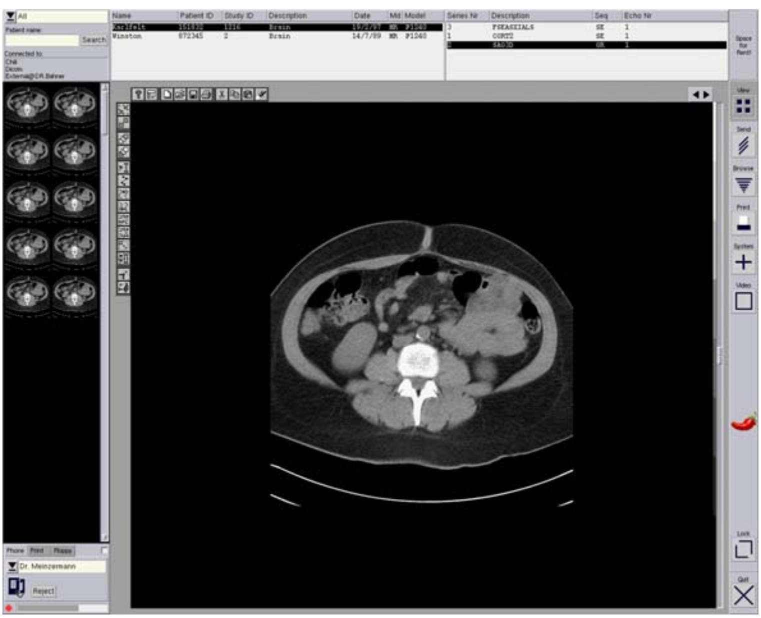

Figure 10. The image shows the last design prototype of the CHILI system, right before implementation began. Most metaphors of the MEDICUS system are gone. They have been replaced by more traditional computer components and concepts.

This is an adaptation to the increased computer knowledge of the users and to the terminology and technology used in the surrounding computer support systems.

Using folded areas, there are parts of the interface that you can hide or make smaller. In the folded state up to 85% of the screen space is available for images. The remaining 15% is for control of the application. The corresponding ratio for the unfolded state is 70/30.

Additional input for design

It is possible to have the application provide additional background information to improve subsequent versions. The logged data can give a more true view of how the system actually is used, compared to standard questionnaires or quick observations on site. By studying the system usage we can learn more about the environment where it is used.

The CHILI application logs some non-sensitive parameters, for example how many images were viewed or transmitted in a session. The logs can later be analyzed to provide a richer view of how the user group as a whole is using the system. This improved view will help us understand actual usage patterns; there can be a large difference between stated and real use.

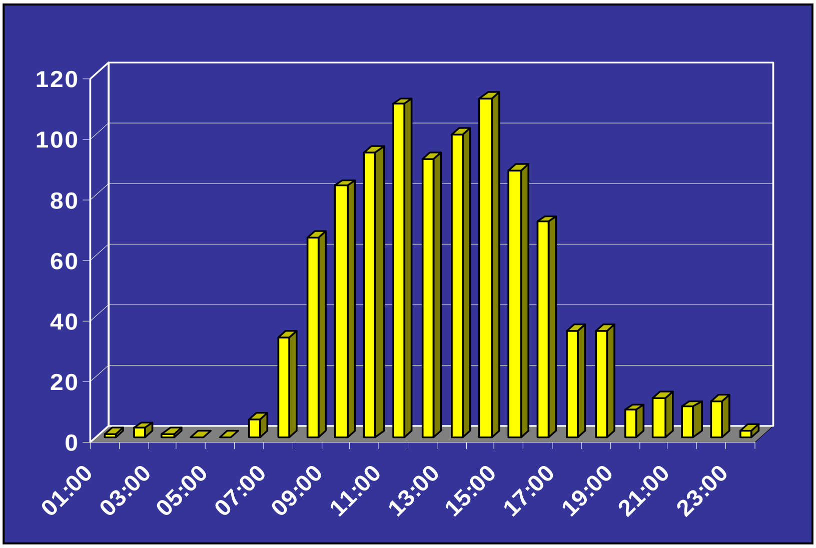

Figure 11. The graph shows the time of day when the application is started. We see it is typically used during normal office hours, although there is some usage late in the evening.

The data shown in this section comes from one month's logs in year 2000. It is not to be seen as invariant. A profiling needs to be updated from time to time.

In cases of severe cerebral trauma or hemorrhage the decision of a neurosurgeon about the further treatment is a time-critical factor. Some hospitals claim, for example, to use telemedical systems for this kind of emergency situations, when the hospital's senior radiologist is backing up junior staff while being at home during night shifts. From the logged data we may see if usage claims like that holds true or not. By looking at when the application is launched, one can construct a better profile of usage. Just by looking at *Figure 11* we may not be completely sure though. It instead supports the view that the system for the most part is used during normal office hours.

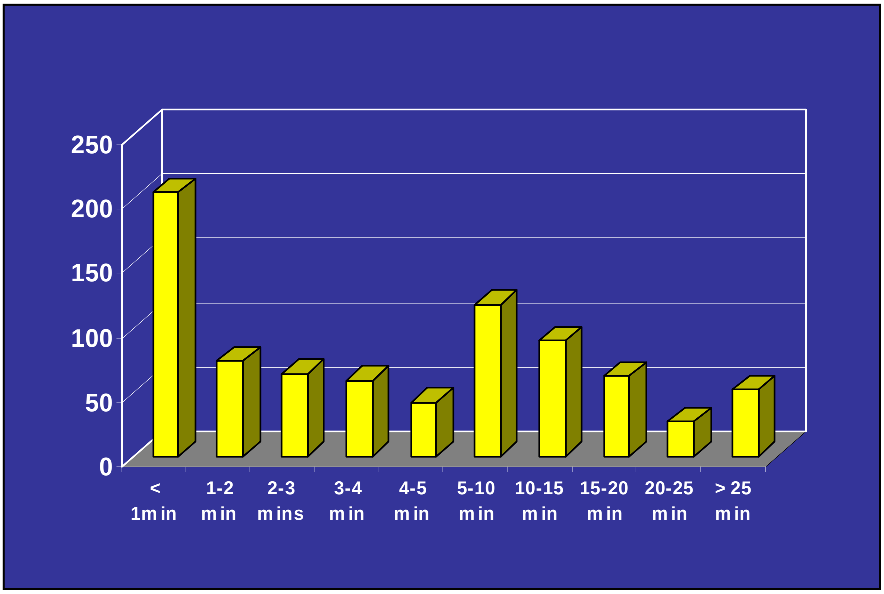

Figure 12. The image shows the length of a conference session using the application. We can see most conference sessions are extremely short. The scale on the y-axis is the number of conferences initiated.

The same type of analysis can be used when looking at the built-in conference functionality. *Figure 12* shows the lengths of joint conference sessions. The majority of sessions are surprisingly short. If this is the case over a long period of time, we should address this in the system design. We could keep the initial setup of conference calls very short in order to control overhead costs.

As an example of when this kind of log data is the most valuable, we can examine the result in *Figure 13*. If we did not have hard evidence like this graph, it would be close to impossible to claim the usage pattern looks like this. From the data we can now conclude that conference sessions have become a regular part of the work – sessions are scheduled to happen right after lunch. Knowing this, we may better adapt the user interface to handle this expected type of activity. We can, for example, provide short keys for establishing a conference session, we can provide a pre-made list of common conference partners, we can reduce the number of interaction steps required to setup a session, etc.

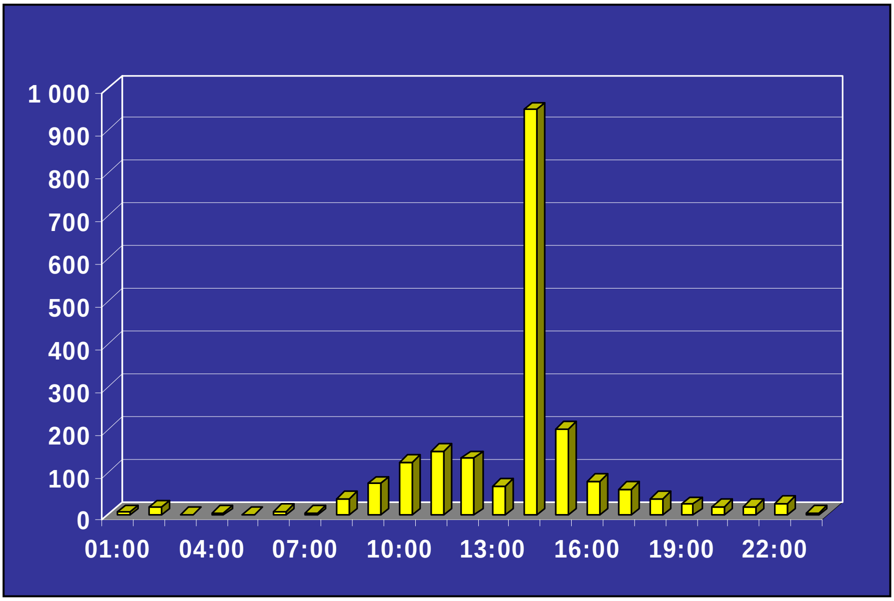

Figure 13. The graph shows the time of day when conference sessions are held. The scale on the y-axis is number of conferences.

Evaluation methods

Several methods were used in the evaluation of the system. The use of a number of methods helps in providing a more complete view of the system.

The first method used is a validated questionnaire. It is used as a benchmark, to find a rough indicator if the usability is as expected.

A few extra questions are added to the questionnaire to broaden the fact gathering and statistics.

Interviews were held with experienced users, to find out more in detail. An interview can provide a lot more information about how well the system works in a real setting.

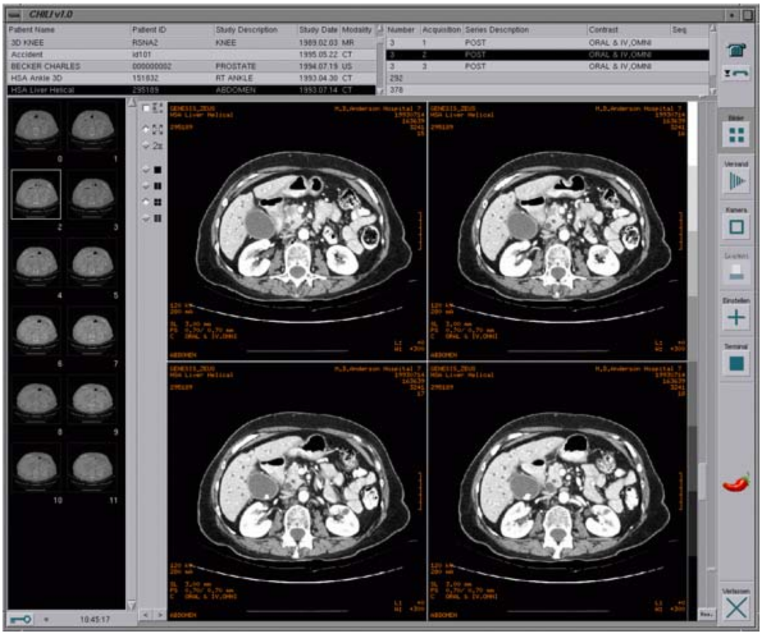

Figure 14. The CHILI system, version 1.0.

System Usability Scale (SUS)

SUS was developed as part of the usability engineering program in integrated office systems development at Digital Equipment Co Ltd., Reading, United Kingdom.

It is a reliable, low-cost usability scale that can be used for global assessments of systems usability. It can be compared to other, somewhat more complex and inclusive methods for measuring usability, like the more known Software Usability Measurement Inventory (SUMI). SUMI is a generic usability tool that comprises a validated 50-item paper-based questionnaire in which respondents score each item on a three-point scale (i.e., agree, undecided, disagree). SUMI is only available as a commercial option [18].

The SUS is simple, ten-item survey giving a global view of subjective assessments of usability. This measure can be used to compare usability across a range of contexts. Just like the SUMI it is a validated questionnaire. SUS was preferred for its easy deployment and minimal footprint.

SUS questionnaire

The SUS questionnaire consists of the ten questions below:

1. I think that I would like to use this system frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well integrated
6. I thought there was too much inconsistency in this system
7. I would imagine that most people would learn to use this system very quickly
8. I found the system very cumbersome to use
9. I felt very confident using the system
10. I needed to learn a lot of things before I could get going with this system

All questions are answered in a Likert scale, rated 1–5. The answers are then calculated into a number in the range 0–100.

> *The SUS score is 2.5 times the total sum of q1-1, 5-q2, q3-1, 5-q4, q5-1, 5-q6, q7-1, 5-q8, q9-1, and 5-q10.*

Results

The graph *Figure 15* shows the collected SUS scores. The average score is 71.

The lowest score is about normal which still is a good result.

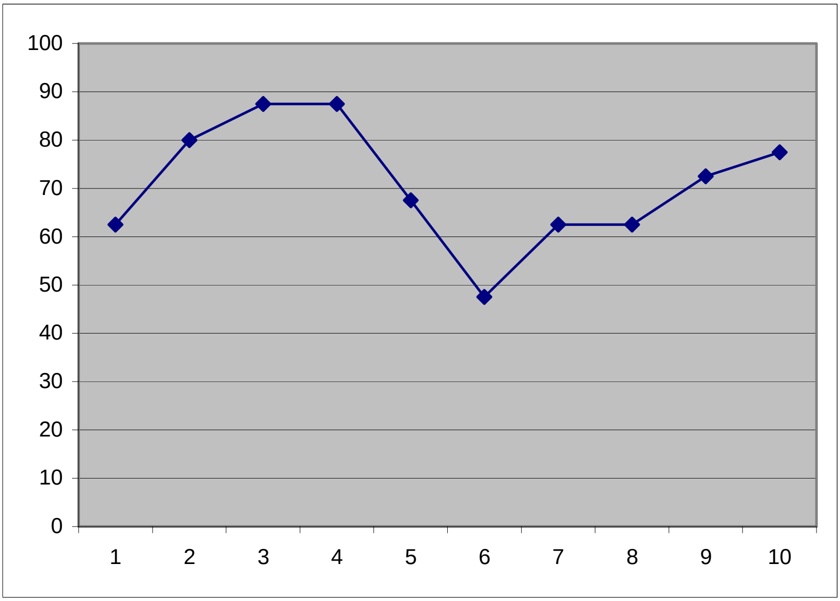

Figure 15. SUS scores from the questionnaire for the ten users. The lowest value reported is still about average (47.5).

Questionnaire

A printed questionnaire with a total of 43 (including the 10 SUS) questions were distributed to users of the CHILI system. The questionnaire was also available as a fill-out form on a web page for those that preferred that.

Results

10 test subjects filled out the questionnaires. 80% of the users are very experienced, having used the system for longer than a year.

Although the system is used frequently (all users use it every working day), each session is rather short. 70% report they use it less than 30 minutes per day.

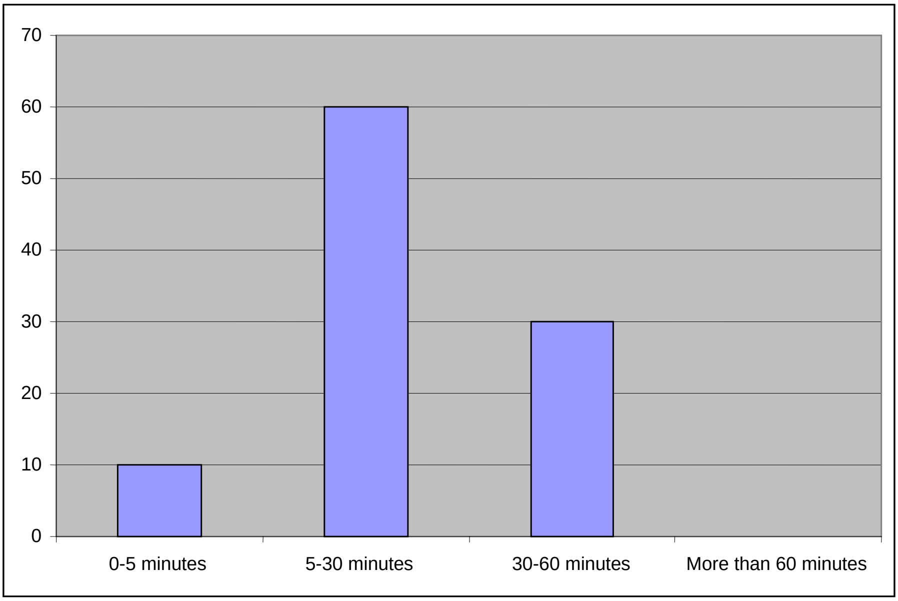

Figure 16. How long do you use CHILI on average per day? X-axis in percent of users.

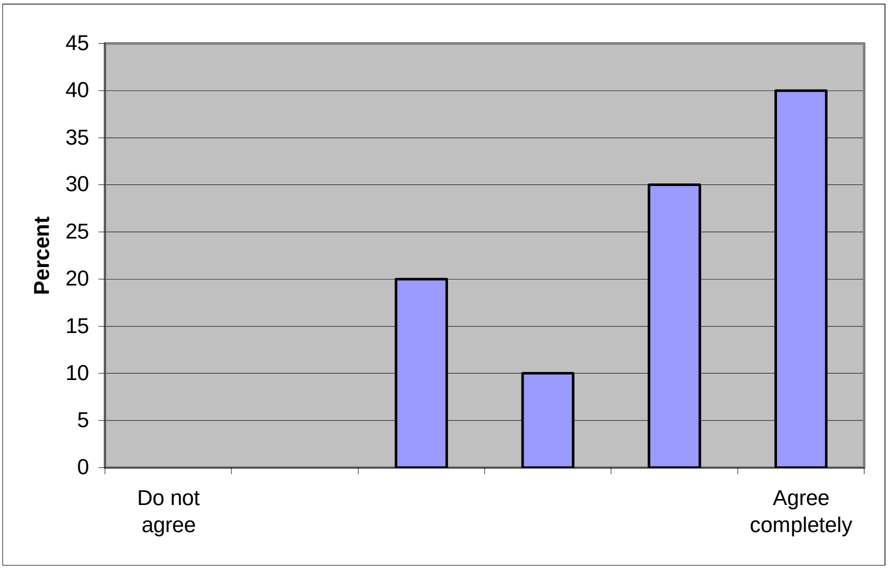

Figure 17. The users (you and your colleagues) have all the necessary skills and education to use CHILI.

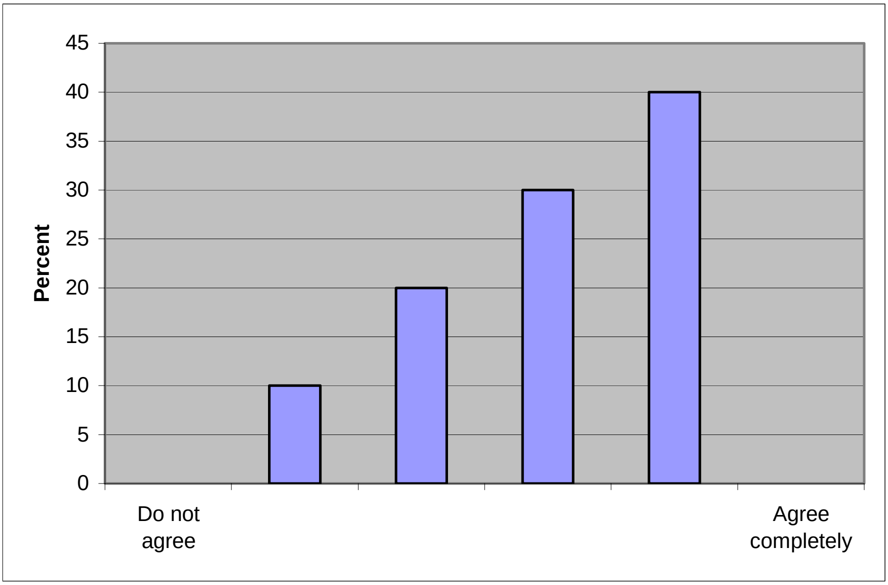

Figure 18. CHILI provides a good view of what it can do.

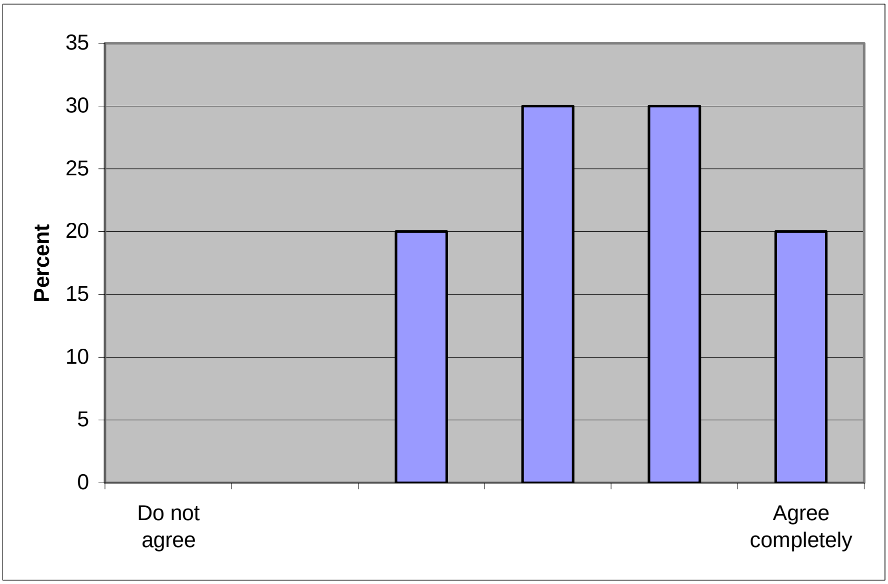

Figure 19. CHILI is easy to learn and use.

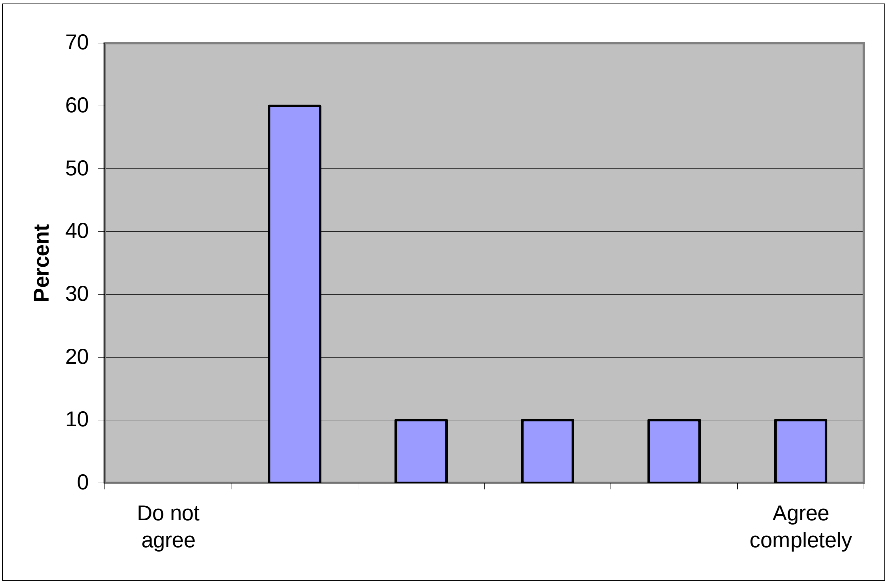

Figure 20. The help functions in CHILI are easy to use.

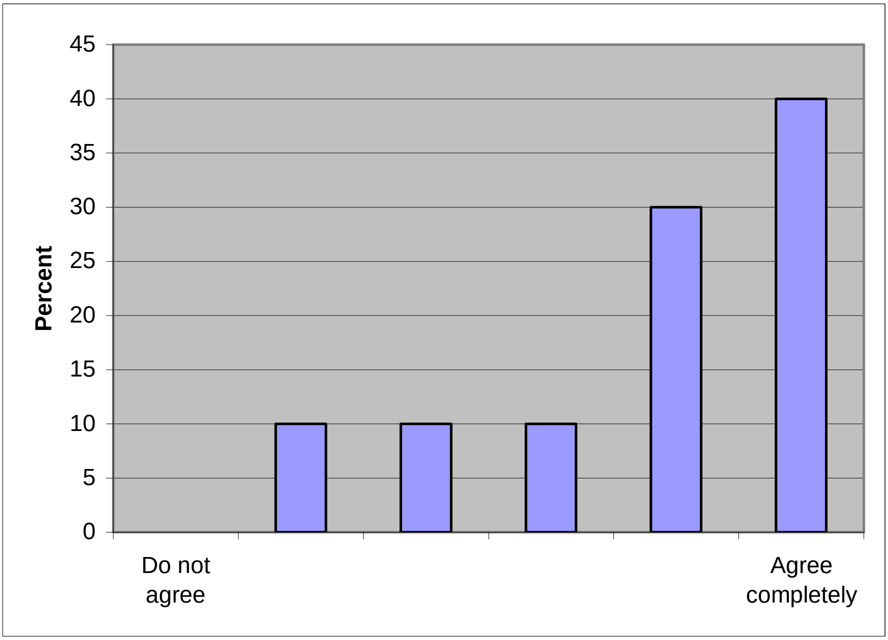

Figure 21. CHILI is flexible and does not control the way I want to work.

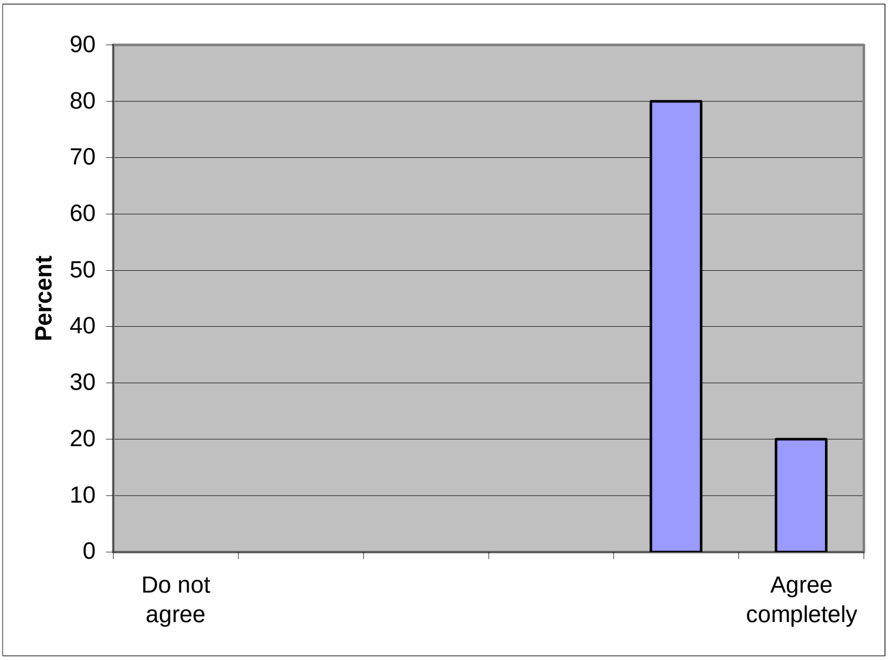

Figure 22. The patients gain direct or indirect benefit from CHILI.

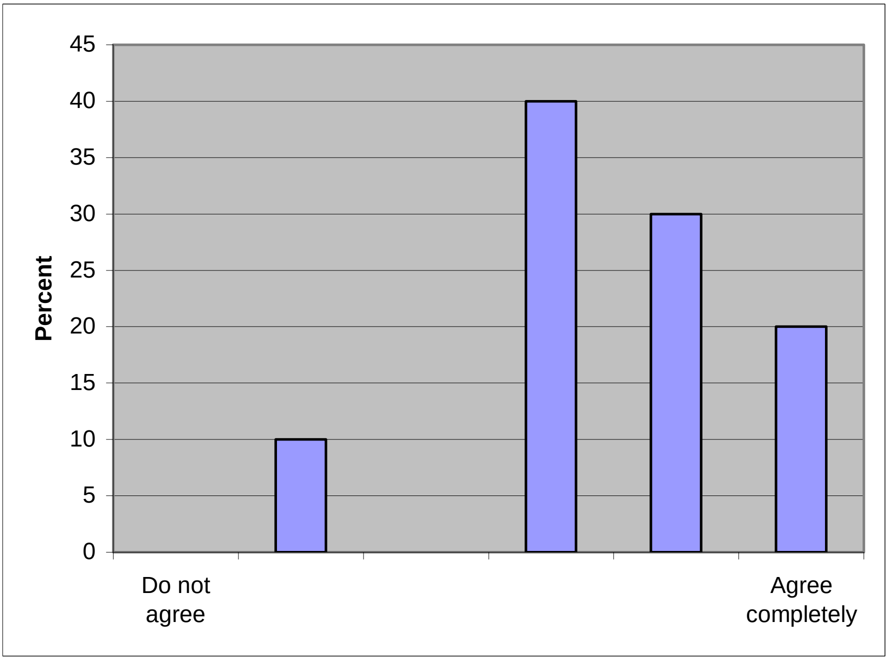

Figure 23. CHILI makes communication easier internally.

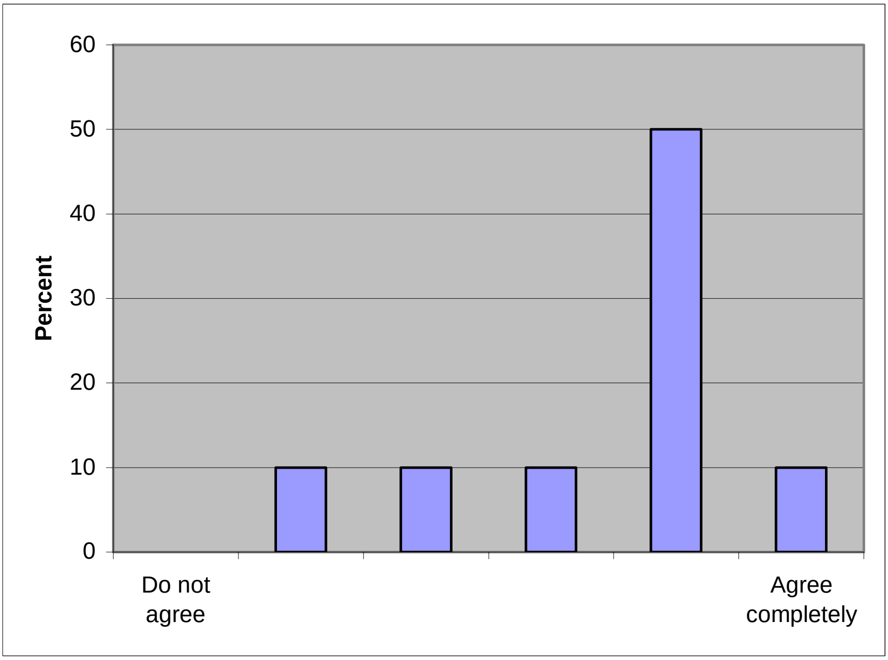

Figure 24. CHILI makes communication easier with external units.

Interviews

The interviews were done on location in the departments of the test subjects. The test group consisted of five very experienced users at the German Cancer Research Center in Heidelberg, Germany. The test subjects ranged from scientific researchers to supervising physicians, all with many years of experience from the medical field but also from using the system. All have experience from using similar systems by other companies.

1. **Not physical**

   What is the best consequence of going from physical images to digital?

   What is the worst …?

   Do you think you there is something lacking when you do most diagnosis on the computer screen?

   What are the practical changes because the work is mainly done on computer screens?

2. **CHILI work well together with the other systems I use**
3. **CHILI is flexible and does not control the way I want to work**
4. **CHILI makes it possible to follow up results**
5. **CHILI makes communication easier internally**
6. **CHILI makes communication easier with external units**

Figure 25. Excerpt from the interview guide. The questions may seem biased but it is the task of the interviewer to neutrally guide the discussion and let the interviewee(s) describe things in their own terms. The guide is there so the same aspects will be covered by all subjects.

Method

Interviews can either be structured or unstructured. In a structured interview, the researcher asks explicit questions consistently to all participants. The interviews were guided by a pre-made set of questions (an interview guide) so that the same topics were covered by all test subjects. The main approach is depth interviews (one-on-one interviews). This kind of inquiry is a form of qualitative research, which emphasizes the need to stay true to context.

Interviews were done in-situ in a quiet room with no one else present. The interviews were recorded with a digital recorder and saved as digital audio files for processing later on.

The resulting audio files were not transcribed. Instead they were analyzed by making freehand notes during repeated playback. The notes were then used to find patterns of relevance. How something was said can be just as important as what is said. The comparisons of notes are added to the note-taking, called *coding* in Grounded Theory [19, 39]. Then categories are identified and their properties. With coding, certain theoretical suggestions will occur. These may be about links between categories, or about a *core category*: a category which appears central to the study. As the categories and properties emerge, they and their links to the core category provide the result/answers.

The primary aims in conducting these interviews were:

1. Find out more about perceived usability.
2. Explore underlying factors affecting usability.

The questions were very much focused around the daily use of the system. From the interviewee's answers a follow-up was attempted to find out why they responded the way they did. The in-depth questions concentrated on the following areas:

- What the opinions are based on.
- What they would like to see instead, in case of a problem.

Results

Overall, the system is considered to be valuable and well suited for its purpose. There were users that said they were able to use the system, but they still had objections to some solutions or functionality.

The reported strengths came from the simple design and the focus on the task at hand.

As always with complex functionality and large data sets, one problem area identified was wishes for faster response times for some operations, for example the video loop through a large serie of images.

There are questions regarding certain functionality, whether it performs the expected way or not. The problem is not the functionality itself, but instead how the functionality is calculated. An example of this is typical image processing functions – how the Level/Window[2] (L/W) setting is calculated when there's more than one image. Adjusting the L/W for a series of images made some users hesitate whether the same setting now was used for each image or not.

Next follows the identified categories and the results from the notes analysis:

Mode behavior not expected

From a developer's point of view, it is easier to design and implement functionality that depends on the specific situation (so called *mode-dependent behavior*). For example, entering text in an editor is only possible to do when in the "editing mode"; printing of a web page is only possible after the whole page has been downloaded etc.

Users expected the system to provide its functions without modes. If they know about a tool, they want to be free to use that tool independent of the context.

In CHILI, there is a video tool that allows one to play a series of images as if it were a video. This video replay should always be available users reported – not just in a video play mode. There are technical reasons or diffi-

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[2] Because medical images contain more information (in grey values) than possible to show on a standard display one selects a setting that best displays the wanted information. The window defines a range of values to map between black and white; the level indicates a value to center the window on.

culties to provide all functions in a modeless manner, but this is, from a usability point of view, important aspects that are worth improving on.

Control on decisions affects appreciation

It was noted that users who have some control over the systems used clearly have a higher appreciation of the systems. Control means the user has a saying when deciding what system to use, or how the system is going to be used and so on.

The control did not need to be absolute in order to gain the positive effect. It was enough if the user had some minor input in the decision process.

In the same way, users that are closer – by having a personal or professional relation or having a similar academic background – to the system support/developers feel they have some control. This, in turn, makes them more enthusiastic about the whole system.

Skill, support and training

The most noticeable finding is the desire to have more assistance and training. Users generally do not request or need more functionality, but are unsure if they know all there is to know! They are not sure they use the system as intended. Likewise, they are not always confident they know enough about what the system can do.

The user's guide, or manual, is available on-line within the system itself, as a well-formatted and indexed electronic document. It is, as most manuals, substantial in size (more than 200 pages long) and users hesitate to use it. Even if the manual has an index and it is possible to search for keywords, it is thought of as a printed manual and regarded not to be appropriate or useful.

The most common request was for a quick reference – a pocket guide – with the most frequent operations. In the same page they also requested an area for notes about system updates or any other new functionality.

It was a common view that the user's guide needed to be complemented with a low-tech guide for common functions. This was requested even though the interviewed users know and master these common functions.

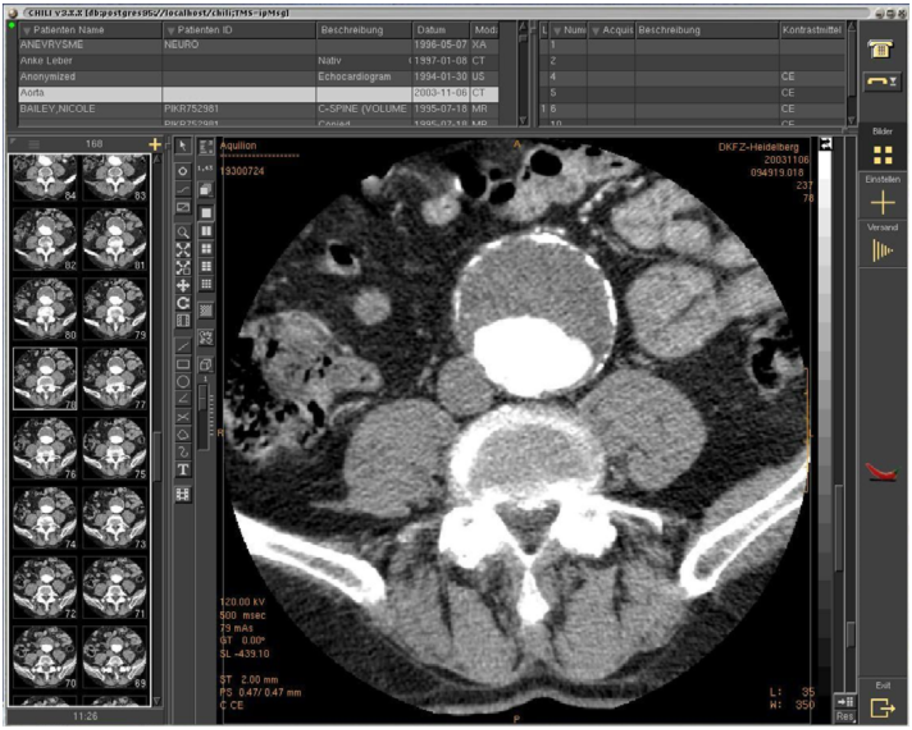

Figure 26. The image shows the next version of the CHILI system, version 3.0, to be released late in 2004. We see the original layout from 1995 is still used, although with a lot more modern look and feel.

Activities

The interviewees claimed that they had no problem in finding information (=images) using the system. This includes organizing, searching, and browsing through large collections of data. Given the amount of data available in the system and the many search possibilities this was surprising.

Users reported that they are used to search for patient data, and that they also store data in such ways that they easily can find it the next day or week.

Integration

For daily use, the system is valued as an integrated part of the work. It is not seen as a separate tool. This is explained by the professions image-centric nature, and that images are so natural that images processing systems are integral parts of the job.

Invisible updates

All users were aware updates are made to the system from time to time. However, most changes are not directly visible. This caused some uncertainty whether the updates meant something specific for them.

This relates to the previous issue of skill – an update to the system was always appreciated (as it by all users was considered to be an improvement, a step forward) but at the same time the update introduced an uncertainty. Users wondered if there was something they need to change, in using the system because of the update.

The conclusion is that the system (or documentation) should contain a log of changes, and categorize them into purely technical issues and ones relevant for a typical user. The latter being changes that has any direct consequence for the user.

Requests for enhancements

The way requests for enhancements (RFE) were talked about resembled the issue of control over decisions. There was a clear connection between the RFEs and perceived usability; if the user got feedback (even a rejection, if satisfactorily explained) to his or her RFE, a positive view of the system was maintained.

Conclusion

The emphasis and focus on the *medical work content* when designing computer support systems was proven to be a working method.

As suggested by Landauer, the most promising factor of improvement of work efficiency lies in evaluation and redesign [21]. The cost (in terms of work effort and financial investment) of doing redesigns is low [30]. This aspect has been used extensively in the CHILI development. The project has built on a stable framework that has, more or less, remained unchanged since its first version. In combination with persistence and long-term iterations, the usability and maturity of the system is a lot easier to control and improve.

Redesign

The stable framework is, I argue, not a stroke of luck. The initial position was that usability should not be an afterthought. Testing and fixing a system after it has been built is inefficient and unlikely to produce good results. Reduced development costs (costs incurred from fixing poorly designed solutions) will further strengthen an approach like this.

The used method of designing according to a number of design rules has helped the development team to address usability aspects. I believe this is important to mention, although other approaches could likely also be of help in the same sense. The conclusion being that good usability never happens by chance. Usability is seen as part of the product development process instead of being a separate activity.

Becoming one of “them”

The fact designers often design for themselves is a concern in any discipline. There sometimes is also a concealed view of users being all alike and similar to the designers. This is a twofold error. The designer is likely an expert on interaction and using computers – most users are not. The designer is rarely or never really insightful in the field of the developed system – the users are experts in this field.

The current CHILI design is based on development and redesigns over a ten year long period. It is easy to think one becomes an expert in the field because of this lengthy involvement. However, as shown by the interviews there are still many things to learn about the environment where the system is used and what users do with the system. As designers and developers we must not forget we never are the users. Also, from this long development one can learn that software development is not a definite process, but an empirical process that requires monitoring and adaptation. So although one has a vision of the functionality and maybe even the end product, the vision must adapt to the changing and evolving requirements of the end users.

A user-centered design approach believes in an evolutionary approach where requirements get continually refined based on user input and testing. The active involvement of users and a clear understanding of user and work tasks will help designers make an appropriate allocation of function between users and technology.

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