

Co-constructing shared understandings of work practice for system design

The interplay of views

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Abstract

This paper examines the collaborative activities of radiology practitioners, designers and fieldworker/researchers in a work practice oriented multiparty design intervention organised in connection to an experimental teleradiology project. Through an example of image comparison in radiologists' image interpretation the participants can be seen to co-construct shared understandings of radiology work practices and teleradiology design issues. The focus is especially on how the views and understandings are at interplay in the collaborative activities of analysing existing work practices, evaluating the experimental system and envisioning a future teleradiology system and work practice. The possibilities opening up from the integration of work practice and collaborative design are discussed in terms of gravitation to actual work practices and practitioners' participation in the workshops.

Keywords: Co-construction, views, understandings, work practice, system design

Introduction

This paper reflects upon the co-construction of shared understandings in an endeavour to evaluate and redesign an experimental teleradiology system through work practice based multiparty interventions. The work that goes into the co-construction of shared understandings is examined here through a detailed analysis of the workshop participants' collaborative activities and discursive practices. This paper joins and builds on the small body of work that attempts to integrate ethnographically informed work practice studies and participatory design (see i.e. Blomberg, Suchman et al. 1996, Mogensen & Shapiro 1998, Simonsen & Kensing 1997). I continue from the observation (Kensing & Simonsen 1997) that users' multiple views on the current work practice can be achieved for design purposes through an ethnographically inspired approach. Here the focus is especially on how the views and understandings are at interplay in analysing the existing work practice, evaluating the experimental system-in-use and envisioning a future teleradiology system.

Despite the growing numbers of attempts at integrating work practice studies and system design (see i.e. Blomberg 1995 for a review; COMIC Deliverable 1994 for uses of ethnography in design; Plowman, Rogers et al. 1995 for an assessment of workplace studies for design), the fields of CSCW and Participatory Design have been quite apart. There is no explicit commitment to direct user participation in the CSCW design (Kensing & Blomberg 1998), in fact, some have argued that it is too problematic to have

users directly involved in design (Hughes, Randall et al. 1993). Therefore, the opportunities for exploring practitioners' participation, their views of work practice as well as their contribution to design in such ethnographically informed CSCW design have been rare.

Several researchers in participatory system design have carried analyses of interactions between users and system designers (i.e. Timpka & Sjöberg 1994, Trigg, Bødker et al. 1991). Although Participatory Design traditions are the most work oriented ones within the design field, the techniques and methods developed are, nevertheless, technology-centered; the participants typically have as a common object a mock-up, a prototype, etc. (Bødker et al. 1993) which directs the attention to the technology which is framed by designers' assumptions. Furthermore, the techniques are future-oriented; the participants are encouraged to imagine their prospective technologically mediated work which leaves less room for the exploration of the actual work practices. The taken-for-granted design interest implicitly suggests for 'challenging' the practice (see i.e. Mogensén 1994) rather than appreciating it and grounding on actual existing work practices.

I am not aware of any detailed analyses of interactions and activities in multiparty settings to bridge work practice and cooperative design. Here I provide reflections on the relations and interplay of views in actual settings where practitioners, designers and fieldworker/researchers come together. The collaborative design event discussed here is one of the WPASED (Work Practice Analysis, System Evaluation and Design, see Karasti 1997b) workshops organised in connection to an experimental teleradiology project. They were intended as a series of interventions to a teleradiology project in a phase where the experimental system had been in clinical use and it was time to evaluate it for further development. This article concentrates on the first one of the workshops where the theme was the radiologists' image interpretation part of the teleradiology system. The co-construction of shared understandings of image comparison, which is one central aspect of the radiologists' image interpretation work, is described through elaborating on extracts of transcripts to illustrate the unfolding interplay of views in course of the workshop. The last part of the paper discusses the relations of the elaborate mixture of participants' views and their contribution to the joint analysis, evaluation and redesign activities. The possibilities opening up from the integration of work practice and collaborative design are discussed in terms of gravitation to actual work practices and practitioners' participation in the workshops.

Background and workshop

The workshops were organised in relation to an experimental teleradiology project. An experimental teleradiology system based on personal computers was developed to meet the needs of primary health care centers with X-ray services (Reponen, Lähde et al. 1995). Fieldwork was carried out during the clinical use phase when the clinicians in Kuusamo consulted a radiology expert in Oulu University Hospital. Emphasis was in studying the actually occurring teleradiology practice in everyday settings in both locations by participant observation, in situ and stimulated recall interviewing and videotaping. Workshops were organised at a point where the clinical use experiences and fieldwork findings could be used in evaluating and redesigning the teleradiology system. They attempted to integrate researcher's fieldwork based understandings of radiology work practices and teleradiology issues into the until then technologically oriented design process and to concretely offer back researchers' views for the workshop participants to

work on. An overview of the work practice oriented part of the project can be found in (Karasti, Reponen et al. 1998).

A wide range of participants was gathered to the workshop (see Table 1). Clinical radiologists provided multifarious situated, partial views of the traditional and teleradiology system related work practices 'from within' as they held different clinical specialities, were differently positioned in the health care system, in regional and university hospitals and different levels of hierarchies of medical institutions.

A - (tele)radiologist, responsible for the daily clinical work with the experimental system in OUH, expert in the kinds of cases expected for consultation from the primary health care center
B - radiologist in OUH, has used the system in covering for A (appears only on the video collage)
C - radiologist in a regional hospital, research interests include teleradiology and digital imaging*
D - radiologist, head of MRI (Magnetic Resonance Imaging) department in OUH*
S - senior physicist, technical expert in the clinic of radiology in OUH*
P - junior physicist, technical support person during implementation and clinical use phase*
L - designer in company responsible for image display and scanner interface applications*
T - designer in company responsible for telecommunications and database applications*
K - workshop facilitator, researcher in CSCW and HCI
H - workshop organiser, fieldworker, researcher in work practices and system design
* - member of initial design team

Table 1. Workshop participants

The video collage (see Table 2) was prepared to make visible existing work practices and to provide rich, detailed and naturalistic material for collaborative analysis. The video collage begins with the traditional film-based way of working with light screen and alternator technologies (clips 1-2). Clip 3 presents an image interpretation session of emerging teleradiology work practice based on digital images on high resolution monitors and computer workstations. Then the video collage proceeds into an array of teleradiology system use situations presenting three specific topics of monitor image interpretation. Clips 4-7 show the initial layout of images in the beginning of an interpretation session on computer screen. Clip 8 demonstrates the problems in having to join patient's images transferred in several packets. Clips 9-14 are instances where different image processing functions are used in monitor interpretation and reporting.

Clip 1 (0:59)	An entire image interpretation session of a 'routine' thorax control case in the traditional environment, sitting in front of an alternator radiologist A interprets two films mounted on light screens, consults patient's film bag for comparison with old films and dictates a report.
Clip 2 (5:54)	An entire image interpretation session of a 'complicated' case in the traditional environment, radiologist A interprets four films hung on light screens, interrupts dictating, rereads the request and parts of the patient's roentgen history, consults the patient's folder for old films, mounts one of them, rewinds the dictaphone, continues with interpretation and reporting.
Clip 3 (3:02)	An entire teleradiology image interpretation session of a thorax control case, a successful case of image layout. Radiologist A says: "good, good, these came side-by-side" as two thorax images appear abreast on the computer screen.
Clips 4-7 (total 3:08)	Four clips of teleradiology system use show how next patient is chosen and how the request and images are displayed on the screen in the beginning of an image interpretation session.
Clip 8 (1:42)	An edited clip of radiologist B demonstrating how the images of one patient transferred in two packets can be joined for simultaneous display on the screen in the teleradiology system
Clips 9-14 (total 3:39)	Each clip shows an instance where the available image processing functions (i.e. flipping, rotating, moving, step-wise size changing, enlargement by cropping, adjustment of greyscale) are used in actual sessions of image interpretation and reporting by radiologist A.

Table 2. An outline of video collage (total length 18:24)

The participants of the workshop co-viewed sequences of the video collage interleaved by discussions. This observable regularity was made use of in chunking the transcript into episodes for analyses (see Figure 1). In the following these episodes are referred to in positioning the reader to the corresponding phases in the workshop.

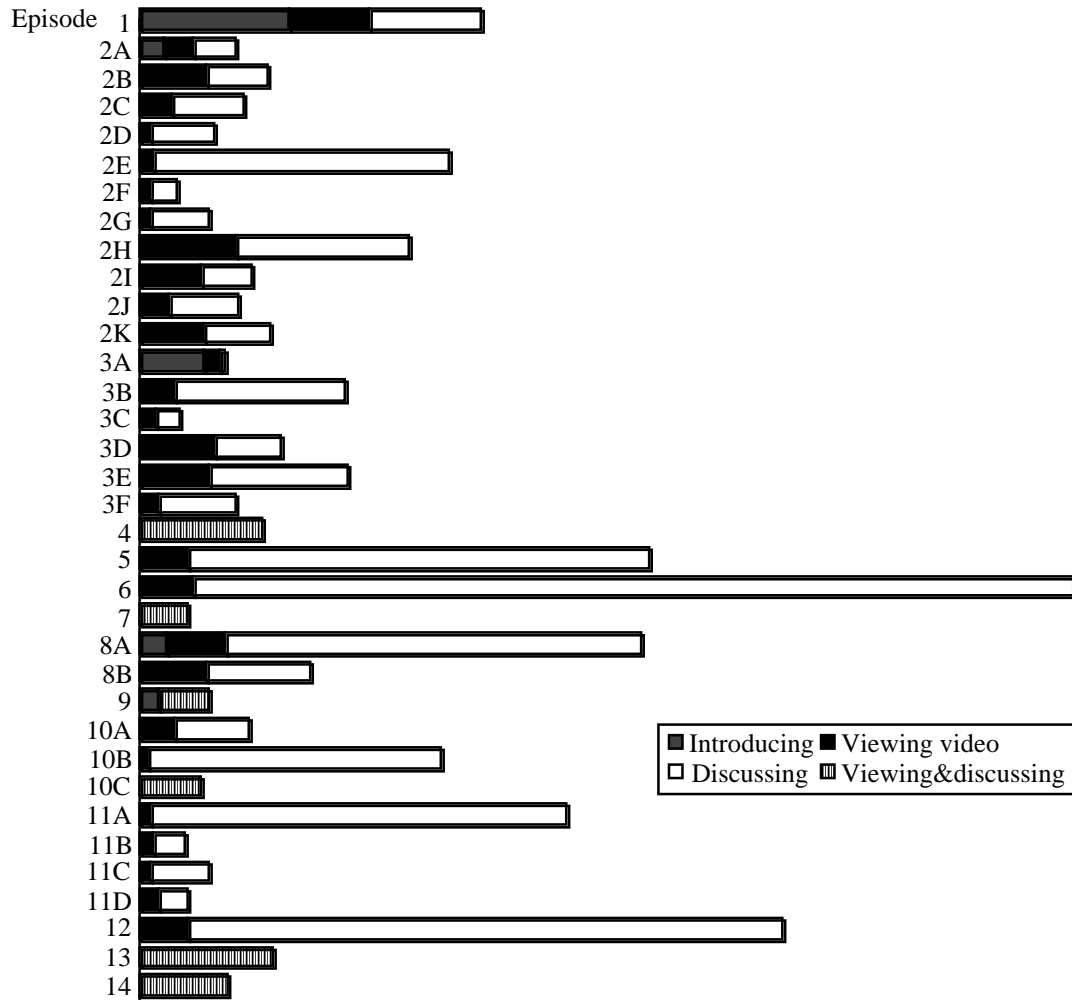


Figure 1. Workshop episodes

Co-constructing shared understandings of image comparison

This chapter describes how the participants collaboratively constructed shared understandings relevant for teleradiology system design of one central aspect of the radiologists' image interpretation work. Reconstructed of excerpts of discursive practices¹ the example of image comparison explores through the unfolding activities and interplaying views how the understandings are elaborated and changed in the workshop.

¹ Image comparison was discussed recurrently in the workshop, in episodes 1, 2B, 2C, 2E, 2G, 2I, 2J, 3B, 3C, 3D, 3E, 5, 6, 8A, 8B, 10B, 12, 13, 14.

Analysing image interpretation in the film-based work environment

Collaborative activities in the workshop are grounded on viewing and analysing the unfolding activities and events of actual work practices represented in the video collage.

The rationale and infrastructure of image comparison. The workshop starts with participants co-viewing an image interpretation session of a 'simple' thorax case carried out in the traditional film-based environment (Picture 1).



Picture 1. In video clip 1 radiologist A sits in front of an alternator, facing two films mounted on light screens, patient materials in folders on the table. In this 59 second sequence he interprets two films mounted side-by-side on light screens, occasionally juxtaposing a third thorax film in his left hand with the mounted ones. Simultaneous to interpreting the images he dictates a report to a dictaphone in his right hand.

Pointed by K to the use of "that side film" (Transcript 1, lines 1-2) radiologist A characterises image comparison in the traditional film-based environment. He explicates the use of several films for comparison (lines 3-6) and the infrastructure supporting the availability of films for the radiologists' expert work (lines 6-11). The possibility to have the patient's previous films from archives allows the radiologist for a unique longitudinal perspective over the patient's changing condition that, for example, general practitioners don't have. Radiologists' professional expertise in image interpretation is based on having access and being able to use all possible image information to discern gradual alterations between progressing diseases and normal variations through comparison of films. The material and technical resources, i.e. films, film folders, light screens, autoalternators, and film archives developed during the century of film-based radiology are an essential element contributing to image comparison in the radiologists' image interpretation work.

	Co-viewing clip 1
1	K: When it goes fluently, it goes fluently. It really does not take long. Something that draws attention
2	there is that you use that side film.
3	A: Yeah there has to be several (images). Often it is so that one has to have several films for
4	comparison, the previous one plus for example a year old one, if one's got it, or maybe a four years
5	old one. Gradual alterations can be discerned there. There are plenty of normal variations and then
6	there are progressing diseases. They bring about changes in different places. As it is, all information
7	is used. A general practitioner may look at one film against a window but does not get the
8	perspective as we do because we can use the light screens and can get films from the archives. When
9	one has to compare with just a certain film and the exposures are same and one cannot for example
10	see behind the shade of heart, one has to use all possible image information material. That is when a
11	roentgen doctor dictates images.
12	K: So dynamics is an essential concern, I mean how the situation progresses, how it changes.
13	A: Yeah, that is one thing that comes up only through image comparison.
	Co-viewing continues with clip 2

Transcript 1. Episode 1

Co-viewing is continued with clip 2 which is almost six minutes long presenting an interpretation of a 'complicated' case. Viewing is paused 11 times as participants engage in a detailed analysis of the unfolding activities of image interpretation (see Figure 1).

Finding an optimal body position in relation to films in comparison. In episode 2B, responding to H's pointer about the observable behaviour on video of changing his position in front of the alternator (Transcript 2, line 1), radiologist A unravels a common practice in comparing two films in the alternator environment (lines 2-5). The radiologists engage in the bodywork of searching optimal spatial relations with the films arranged over the large area of light screens during image interpretation. This is essential, as they need to find a position in middle of the films to be able to see them at a perpendicular angle at approximately the same size. In reflecting about the meaning of the shifting radiologist A distances himself from merely doing the work (line 4). He is able to note the bodywork involved which has gone unnoticed to him yet being an important aspect of image interpretation in front of light screens (lines 5-6).



Picture 2. In the video sequence of episode 2B radiologist A reaches out from the left side to the right side in front of the autoalternator.

	Co-viewing sequence 2B
1	H: So here you change all the way from one end to another, or what is it about?
2	K: Now I got a view at right angles at both of the films, I suppose one needs to reach out. One cannot
3	look from the side at the film, nor at the monitor. In a way, one looks perpendicularly, when
4	comparing two images. One finds a position in the middle of them to be able to see them at
5	approximately the same size in one view. It has to be the meaning of this shifting, I suppose. I've
6	never thought there is so much body-work involved in image interpretation. So it seems to be ...
	Co-viewing continues with sequence 2C

Transcript 2. Episode 2B

Supplementing more old films for comparison during image interpretation. In the video sequence of episode 2E radiologist A glances through the index of examinations on the sleeve of the film folder. He takes out one film, holds it against the light screen to quickly read it and puts it back in the folder. In commenting the sequence radiologist A immerses back in the event of being engaged in going through the patient's previous films in the folder to gain more perspective on the case (Transcript 3, lines 1-2, a similar immersion can be found in Transcript 2, line 2). He identifies a "common pattern of behaviour" in the particular activities of taking out more previous films for the needs of comparison that arise in the unfolding course of image interpretation (lines 3-4). Typically, the patient's film folder is fetched from the film archives, relevant films for comparison are selected and mounted on the light screens and these light screens are temporarily stored in the alternator magazine prior to the radiologist's interpretation session. However, occasionally, as in this case, the radiologist needs to search for supplementary films from the film folder placed on the alternator during the session.

	Co-viewing sequence 2E
1	A: Now I got more perspective. Differently toned old images where the old calcifications can be
2	discerned somewhat differently tinted. They do not stand out with too big exposure, they get burned
3	away. But this is a common pattern of behaviour, to take out more images from the film folder for a
4	specific purpose when the archives are close by.
	(...)
5	D: The point here is that the images that you have there, the ones hung on the light screens and
6	especially the new images, those you read through systematically.
7	A: Yeah, at least I try to read.
8	D: And an image from the film folder, you don't need to mount it for reading.
9	A: True, yeah, I just check a specific region of it, just check a region of interest there.
10	D: Yeah, it is a different mode of action.
11	K: Of different type.
12	A: One cannot himself distinguish the function when one is doing the work, and does not think how it
13	differs from other functions.
	Discussion continues

Transcript 3. Excerpt of episode 2E

Different ways of reading and comparing films. Continuing to characterise typical aspects of image interpretation radiologist D engages A in a more detailed analysis (Transcript 3, lines 5-10). Radiologist D offers his readings of A's activities (lines 5-6, 8, 10) and A aligns with them (lines 7, 9). Together they characterise two ways of juxtaposing individual images for reading. The films mounted on light screen, especially the ones of the recent examination, have to be thoroughly and systematically interpreted whereas the films taken out from the film folder may just need to be read of specific regions. Radiologist A finds joint analysis helpful as he sees himself too immersed in the doing of work to be able to discern certain aspects of it (lines 12-13).

Shared understandings of image comparison in traditional work practice. In the process of co-viewing and analysing two film-based image interpretation sessions the participants create a platform of shared understandings of image comparison in the traditional environment. Radiologists' lived experience of image interpretation becomes voiced in interpretations and evocations, articulated in characterisations of typical aspects of work practice and common patterns of behaviour in work. Through the analysis of actual unfolding activities and events of image interpretation the participants discover aspects of routine work that have been so obvious to be unremarkable to them. In addition to the availability of relevant films (episode 1) participants realise that image comparison is also an unfolding activity enacted in the process where e.g. body positioning has to be found in relation to films on light screens (episode 2B), extra old films may have to be taken out of the folder (episode 2E, lines 3-4) and these films may be just checked for a specific region to confirm a hypothesis (episode 2E, lines 5-9).

Analysing the teleradiology system in use

After two clips of traditional image interpretation co-viewing proceeds to monitor image interpretation based on digital imaging in a computerised environment (see Picture 3).



Picture 3. Radiologist A interpreting images in the teleradiology environment

Juxtaposing traditional and teleradiology image interpretation work practices. The video sequence in episode 3B shows radiologist A choosing the next patient, a thorax control case, from a list of all cases to be reported, and the corresponding request is displayed. He reads it and proceeds to the image display view. The first thorax is gradually displayed on the monitor and as the second image follows radiologist A comments: "good, now these came side-by-side, good, good" (see Picture 4).

After viewing video sequence 3B the radiologists juxtapose traditional and teleradiology image interpretation work practices in order to identify discrepancies and problems. Radiologist A explains his praise in this particular instance by bringing up a recurrent problem in clinical work with images transferred in separate packets for interpretation (Transcript 4, line 2). He continues by explicating why it is essential for the radiologist to have images displayed side-by-side for comparison (lines 3-8). It is a taken-for-granted feature of traditional alternator environment to have simultaneous access to films as the large light screens allow for the side-by-side layout of films.

	Co-viewing sequence 3B
1	H: So, there you comment "Good, they came side-by-side"
2	A: Yeah, it was difficult to merge two packets onto the monitor. It was done through some internal
3	code and nevertheless it is important to have at least one pair of images displayed, like
4	automatically. So if there is an alteration there, how do you know whether it is, let's say, a thirty
5	years old residue of pleurisy. One cannot know from individual changes. Although it is a massive
6	scar, it is not necessarily lung cancer but an old scar alteration that has not yet been calcified. The
7	value of individual alteration is limited, it only gives probabilistic information but it cannot prove
8	anything to any direction before it is known what the situation has been years earlier.
9	C: I'd like to comment that when teleradiology is used the part of the transferring end is also needed.
10	They have to understand that when sending images they also need to include images for comparison
11	D: Another difference that one can easily see in comparison to the alternator image interpretation
12	situation, a difference between light screen and monitor interpretation is that here the images are
13	displayed rather slowly. Another difference is when the radiologist changes light screens to the next
14	case he can at the same time read the request. In this system the monitor is used all the time for
15	image display meaning that the radiologist has to wait all that time.
	Co-viewing continues with episode 3C

Transcript 4. Excerpt of episode 3B

Radiologist C points out that in the distributed teleradiology setting the responsibility for the availability of all relevant images for comparison lies with the sending end (lines 9-10). Radiologist D discerns a breakdown in the familiar way of working through analysing the unfolding process of teleradiology image interpretation on videotape and comparing it with his experiences of traditional work practice (lines 11-15). In the traditional practice of interpreting several cases in a row the radiologist is able to read the request of the next patient while quickly changing the light screens on which prehung patient cases are stored in the magazine of the alternator. In the teleradiology environment the radiologist has to wait idly for the system to gradually display all patient images followed by the request.



Picture 4. Two thoraces displayed on the screen of teleradiology workstation in clip 3

Exploring and evaluating image comparison in the teleradiology system. Detailed analysis of the teleradiology system in use continues (Transcript 5). In the video sequence of episode 3E radiologist A is engaged in interpreting and dictating the two enlarged thoraces that in the beginning of clip 3 became displayed side-by-side on the monitor. Analysing the frozen image display view the participants explore how the screen should be laid out to optimise the size of the images (lines 1-2). They evaluate the system in use

and suggest improvements to the observed shortcomings (lines 3-14). In regard to successful image comparison radiologist C summarises the previously made suggestions of two monitors and black image background as well as reiterates D's proposition of changing the position of the toolbar on the screen in relation to differently shaped images in order to optimise their size (lines 7-9). The implications of the ideas to work practice (lines 12-13) and their technical feasibility are considered (lines 10,14).

	Co-viewing sequence 3E
1	D: Looking at that monitor there makes me think that the images could be somewhat bigger if the
2	toolbar was down there. At least in this case.
3	A: Yeah, the counter light would decrease down there.
4	C: It is to the viewing application then ...
5	L: Should the areas without images be blackened?
6	A: A very good idea.
7	C: The areas where there are no images should be black, fully blanco. And then two monitors, so we
8	could have two windows. Then it could work. ... Should the toolbar, I'm still thinking about D's
9	suggestion and that we have differently shaped images, could we have it like floating?
10	L: Well, at least that it could be quickly changeable, so I think it would be ...
11	C: When we have vertical and horizontal images, it could always be put aside.
12	D: Yeah, or not necessarily, I think that the floating one is not so good. But it could be like in Word,
13	so that you can place it either, on the bottom or on the side ...
14	L: Yes, I think that it can be done quite easily.
	Discussion continues

Transcript 5. Excerpt of episode 3E

Shared understandings of discrepancies in image comparison between traditional and teleradiology work practices. In exploring the discrepancies of image comparison between traditional and teleradiology work practices the participants realise that also the ways of working change. The availability of relevant patient images for comparison becomes more complicated due to the distributed setting of teleradiology service. The problem with merging images from several packets complicates simultaneous access to all available patient images during interpretation sessions. The simultaneous comparison of images side-by-side becomes problematic in the teleradiology environment due to the modest size of computer monitors in comparison to the autoalternator light screens.

Uncovering teleradiology issues

After three clips of entire interpretation sessions the video collage proceeds into an array of teleradiology system use situations presenting instances of initial display of images on radiologist's computer screen in the beginning of image interpretation session (clips 4-7). Clip 5 shows an initial display of four images and a request on the screen.

	Co-viewing sequence 5
1	K: Is that a good way how they are displayed, as an initial situation?
2	A: Yes, it is, it gives a kind of overview of what images have been taken and the request, one can
3	quickly open what one wants.
4	D: What is most important here is that one can see what images there are, it is essential that one can
5	see that this is a front image and a side image and an enlarged image and so forth. But it is a different
6	issue how the arrangement there ... one can see that there the monitor is divided up in a manner that is
7	not the most favourable way to divide the monitor, but how should it ideally be?
8	C: As background why we wanted to have this feature and it was realised I can tell that we wanted to
9	go as close as possible to the light screen metaphor where you just press a button and can see the
10	entire field at once so you can see your next work task. This is like an overview. Then how that is
11	divided, I suppose it depends on Windows' way of doing windows, it is a technical incident. When
12	we were thinking whether the program can be intelligent and know how to arrange the images, we
13	established that it is rather difficult, at least quickly, to come up with a solution and then we ended up
14	with a standard solution where the windows are evenly divided.
15	D: The next point is that then those images have to be arranged by the radiologist in the way that he
16	checks which is new and which is old and which is a new side image and an old side image and then
17	arrange them the same way as if they were hung on the light screen. After they are displayed, it needs
18	to be checked which are new and which are old and then possibly arrange them side-by-side and that
19	requires a lot of work, a lot of work...
20	C: There comes another point, if that could be somehow transferred to the beginning of the task chain
21	or to the program, according to a date or some other factor, the order of images.
22	D: So that a series of images would always come in a certain order and a certain arrangement there.
23	L: Yeah, so that it would be a work procedure issue. In digitising they would do one examination, let's
24	say an old one first, or it could be ordered from the oldest ones to the newest ones, or somehow
	Discussion continues

Transcript 6. Excerpt of episode 5

Dispersed image articulation work of hanging images. The participants analyse the videotaped use situation to find out how the light screen metaphor has become realised in the experimental system (Transcript 6, lines 1-7). From the clinical image interpretation point of view the initial display is good as it provides for an overview of all images in the beginning of a session (lines 2-3). However, the system does not support the comparison of images side-by-side in the course of the interpretation process. The division of windows on screen is not optimal as the participants can see on the video (lines 6-7). And it turns out in the explication of the initial considerations (the light screen metaphor) that the arrangement of images has been solved with a standard solution for windows (lines 8-14).

Radiologist D points out that the teleradiologist would have to do a lot of image handling work to arrange the images as if they were *hung* on light screens before being able to continue his work (lines 15-19). In traditional work practice *hanging images* means the entire business of searching, selecting, arranging and mounting films on alternator light screens. This *image articulation work* is carried out by one of the supportive occupational groups prior to the radiologists' interpretation sessions. The experimental system has changed this division of labour. In the teleradiology environment image articulation work has become dispersed to the personnel in the sending end, to the teleradiology system itself (the display application) and finally to the teleradiologist.

The radiologists are not satisfied with teleradiologists having to engage in image articulation work (lines 18-21), which is seen as "a work procedure issue" for the sending end (lines 23-24) to assure that "a series of images would always come in a certain order and arrangement" to the teleradiologist's workstation (lines 22). The participants realise that dispersed image articulation work is an important issue in teleradiology to be explored in the following workshop focused on the collaborative aspects of the system.

Reconsidering initial assumptions

Episode 8A is a culmination point in the workshop in the sense that one of the central design concepts is spelled out and contested. The participants realise through the obvious problems with *packets of images* that the initial assumptions on which the experimental system is built are in disagreement with the actual needs of image interpretation.

	Co-viewing video sequence 8A
1	H: Did you often do that, that you would take images forth from several packets?
2	A: Well, I used it as little as possible. Sometimes when an image was transferred and displayed, I
3	rapidly read the image and tried to memorise it, so that I would not have to do this phase. ...
4	Nevertheless it was irritating. (...)
5	D: This system is built in a way that only one packet can be opened and displayed at the time. If we
6	think about these workstations for radiologists that are used in digital roentgen departments and used
7	in fetching images from the archives, there the starting point is that the software is always on and
8	then one can choose certain images that one wants to use simultaneously. This one should also have
9	such an option that one could search for the images from the files ...
10	C: This is an interesting matter. The word comparison is important here. In all issues that we have
11	talked about here today. Our original concept was more like solving individual problems. Now, also
12	with this work, it has turned out that even in teleradiology comparison of images is needed and we
13	have to make it possible ...
14	D: What we planned was that a certain thorax would always be accompanied with images for
15	comparison in the same packet. But if this does not work out then what we need is like another
16	function. We need to make another function, like a database solution, where all the patient's images
17	could be seen no matter in which packet they are. They could be fetched along a path, in a manner of
18	speaking, like gathering a single one of them.
19	C: In a way it would be a window to the database material. The basic unit would not anymore be a
20	packet but patient's social security number that could then be used to see ...
21	D: One could see what images there are ...
22	L: Exactly, or so that there would be several, so that one could choose from them, whether it is an
23	examination or a patient. ...
	Discussion continues

Transcript 7. Excerpt of episode 8A

Making visible the problem with image comparison in using the teleradiology system. Video sequence 8A shows teleradiologist B engaged in joining patient images from two separate packets to be simultaneously displayed on the monitor: she opens the first packet, searches for the internal image code, memorises the lengthy code, closes the packet, opens the second one, and through a special procedure of selecting the code of the first packet from a long list of image codes opens the images of the first packet together with the images of the second packet). This complicated procedure requires several minutes to complete. Radiologist A, who has mentioned already in episode 3B about the same problem, emphasises its severity. He recounts of rather resorting to a work-around of reading and memorising images than engaging in the "irritating" procedure (Transcript 7, lines 2-4).

Relating initial design assumptions to actual teleradiology system use. In the course of the workshop the participants have grown aware of the discrepancies between the different environments. Here they see in the videotaped work activities and hear in the comments of radiologist A how the conventional ways of image comparison are disrupted. They start to relate the initial design concepts with their realisation in the system and the implications they bear on the actual teleradiology system use and work.

The experimental teleradiology system had been designed based on an assumption that the service is about "solving individual problems" (line 11). The radiologists had presumed that typical cases for consult would require a timely interpretation of only few images. The need for image comparison had not been explicitly expressed. However, a survey study carried out during the teleradiology system's clinical use period had revealed that only a minority of cases for consult had been urgent ones whereas there had been a lot of control cases with numerous images (as for example the case in clip 8).

The design team had planned that patient images would be transferred in packets of images (lines 14-15) and only one packet would be opened at a time for display (line 5). The problems had manifold during the clinical use period because the transfer of all case relevant images in one packet had failed due to rather unexpected problems with telecommunications (referred to by radiologist D, line 15). The teleradiologists had recurrently been faced with the problem of multiple, incomplete and duplicate packets.

Highlighting: "The word comparison is important here". The participants have gradually gained more informed understandings of image interpretation work and revealed in-depth aspects of image comparison. At this stage of the workshop, image comparison denotes more for the participants than in the beginning when it was characterised as availability of previous patient images (Episode 1, Transcript 1). For example, they have co-constructed the understanding that radiologists' everyday image interpretation work as well as professional expertise are based on having the possibility to juxtapose images side-by-side in simultaneous comparison, both in the traditional as well as in the teleradiology environment. They are ready to reconsider their assumptions as "it has turned out that even in teleradiology comparison of images is needed and we have to make it possible" (lines 12-13). Design concepts more aligned with the actual teleradiology practices are outlined. The system's basic unit was reformulated from *packet* to *patient* and it was envisioned how the teleradiologist could access patients' case relevant images in the future teleradiology system (lines 8-9, 13, 17-23).

Envisioning the future teleradiology system

We have seen in the previous excerpts that analysis and evaluation of the experimental teleradiology system in use tend to proceed to envisioning the future teleradiology system, i.e. finding improvements, formulating requirements and generating design ideas (3E), exploring and identifying the special issues of teleradiology (5), and outlining alternative design concepts (8A). Towards the end of the workshop the discussions become increasingly focused on the envisioned system. The last excerpt (see transcript 8) illustrates how shared understandings are put into use in assessing ideas of future technology support for greyscale adjustment in image comparison.

Clip 10 presents radiologist A selecting one of the four initially displayed images, enlarging it on the monitor and then adjusting its greyscale. Greyscale adjustment is one of the image processing functions available in systems based on digital imaging. In the experimental system there are two functions for greyscale adjustment. One is used to adjust all images on screen simultaneously by mouse-dragging: horizontally to adjust contrast, vertically to adjust brightness and diagonally to adjust both at the same time. The other greyscale function is for adjusting individual images 'from the raw data'. The adjustment is executed through a menu selection for a histogram diagram and then changing the S-curve of greyscale dispersion.

	Co-viewing video sequence 10A
1	C: Radiologist A, did you use the histogram based greyscale adjustment, the one with the curve?
2	A: No, I just used the mouse-based function that works ... the other one was difficult to use ... (...)
	Co-viewing video sequence 10B
3	H: There is some greyscale adjustment.
4	A: There is no need for fixed adjustment there. But there is so much tone difference between the upper
5	and lower part of the image that one has to search for momentarily optimal adjustments for certain
6	regions. I can screen the region on interest with one adjustment. There is no way to have the entire
7	image optimally adjusted with only one adjustment.
8	C: There has to be an option to do it on the fly, simultaneously as you read the image you have to be
9	able to do it.
10	A: Yes, when there is so much difference in tone within an image. (...)
11	K: Is there need for adjustment of individual images then?
12	D: Yes, if we want to compare two images that have been slightly differently exposed. We need to
13	have them with same tones, simultaneously.
14	C: Here we come to an analogy with light screen interpretation. This quick adjustment works
15	generally, as in cases like the 50 seconds image interpretation. But then with difficult, complicated
16	cases, like when you were searching for the calcification and for differently exposed films, then we
17	need more thorough adjustment of individual images. It's like a second generation tool to be used.
18	K: How about setting initial values for adjustment, adjusting images to a pre-set level?
19	S: To a histogram equalisation.
20	K: It would not necessarily be right. But then we should anyhow ...
21	C: But there is now a visual problem there. ... In film based practice we gain a visual registration of
22	the images, how they are in the beginning. We know how to proportion our interpretation to them in
23	comparing images. If the images were even-equalised we would not be able to differentiate what is
24	real alteration of tones and what is inflicted by the program. It may be really minute shades in images
25	that bear consequences, in thoraces. ... We have to be able to stay in control.
26	D: We know that this is an underexposed or overexposed image. And as we know film technology and
27	the anatomical object, and how X-rays penetrate there, we know how this effects interpretation.
	Discussion continues

Transcript 8. Excerpts of episodes 10A and 10B

Drawing on radiologist A's unique experience with the experimental system. The mouse based greyscale function is discussed and evaluated based on viewing and analysing radiologist A using the function in his videotaped work (Transcript 8, lines 4-10). Radiologist A explicates his usage of mouse based greyscale adjustment on the tape (lines 4-7). He stresses how the adjustment is intertwined with the simultaneous process of interpreting images that have a lot of difference in tone between different regions within one image. Reading such images is possible through finding an optimal combination of contrast and brightness for a certain region of interest within an image at a time. Based on his experience with the system he doubts whether it would be possible to find one adjustment that would be optimal for all regions in such unevenly exposed images. Aligned with A's explication radiologist C continues that greyscale has to be adjustable "on the fly", simultaneously while reading the images (lines 8-9).

Justifying with analogies of previously co-constructed cases. Radiologist A has not used the histogram based greyscale adjustment function due to its cumbersome user interface (lines 1-4). Asked about the function's necessity in the future system (line 11) radiologists speculate about the need based on their experience in clinical work (lines 12-17). Radiologist D can imagine that there will be situations where slightly differently exposed images need to be juxtaposed simultaneously with same tones (lines 12-13).

Radiologist C further justifies the necessity of two different greyscale adjustment functions. By drawing on the previously co-constructed understandings he makes his

argument more understandable for the non-radiologist participants (lines 14-17). He grounds his argument on an analogy from the traditional light screen environment by using as examples the two clips of traditional image interpretation viewed and analysed in the beginning of the workshop. The mouse option for rapid greyscale adjustment works for simple cases as in clip 1 ("50 seconds interpretation"). Yet a more thorough adjustment is needed in more complicated cases such as in clip 2 (where radiologist A searched for differently exposed images to confirm his assumptions about a suspicious calcification).

Reasoning with radiologists' professional expertise. A design idea that further exploits the possibilities of digital imaging is put forward. It is suggested that the adjustment of initial images on screen are preset to a histogram equalisation to provide for more evenly toned images to start interpretation (lines 18-20).

The radiologists' professional expertise in clinical image interpretation becomes appreciated and accounted for in the co-evaluation of the idea. Radiologist C points out that there is a "visual problem" with the suggestion (line 21) because it is important for the radiologists to see the initial images to be able to differentiate between what is "real" and "application inflicted" change in image tone. The proposed histogram equalisation of images prior to interpretation session would make it impossible for them to "stay in control" of image tone variations (line 25). Such slight variations in shades and tones that a lay person cannot perceive are an essential part of radiologists' work of *seeing*.

Radiologist D continues the line of argument with radiologists' proficiency in radiological imaging and anatomy (lines 26-27). The radiologists are able to interpret and diagnose poorly exposed images based on their knowledge of how radiological images are produced. Part of their expertise is to flexibly adjust their interpretation to the varying factors in different situations. The detrimental implications of the design suggestion based on the technical potential of digital imaging not apparent to non-radiologists were immediately detected by the professionals.

Using the shared understandings of actual work practice in envisioning future system. The example of assessing the relevance of greyscale adjustment for the future teleradiology system shows participants' grown appreciation for the actual work practice and practitioners' lived experience. Radiologist A's unique experience with the experimental teleradiology system and radiologists' professional expertise are accounted for in considering two existing greyscale functions and a further design idea to exploit the possibilities and bring more added value of digital imaging to clinical image interpretation work. Furthermore, the way in which radiologist C uses the collaboratively analysed clips of traditional image interpretation as shared categories shows not only that the participants have co-constructed understandings of work practices but also that these understandings are put into use for design purposes.

The interplay of views

The integration of ethnographically informed work practice studies with multiparty collaborative design provides for a rather elaborate mixture of views of technologically mediated work practices that contribute to the design process. The participants jointly viewed and analysed the video collage gaining refined understandings of the actual work practices. As there were no predestined analytic coding categories in the workshop, interpretations and evocations of the videotaped instances of work abounded and were interwoven into the mutual co-production of intelligibility. The participants with different

backgrounds, positions and outlooks provided for a multitude of partial situated views of (tele)radiology (technology) and work practices. Juxtaposing and joining, translating and moving between the multivoiced views help in the collaborative process of consensus building where the participants at the same time reconsider and construct their views and understandings. The following describes some of the prevalent views as well as their relations in the co-construction of shared understandings (see also Figure 2).

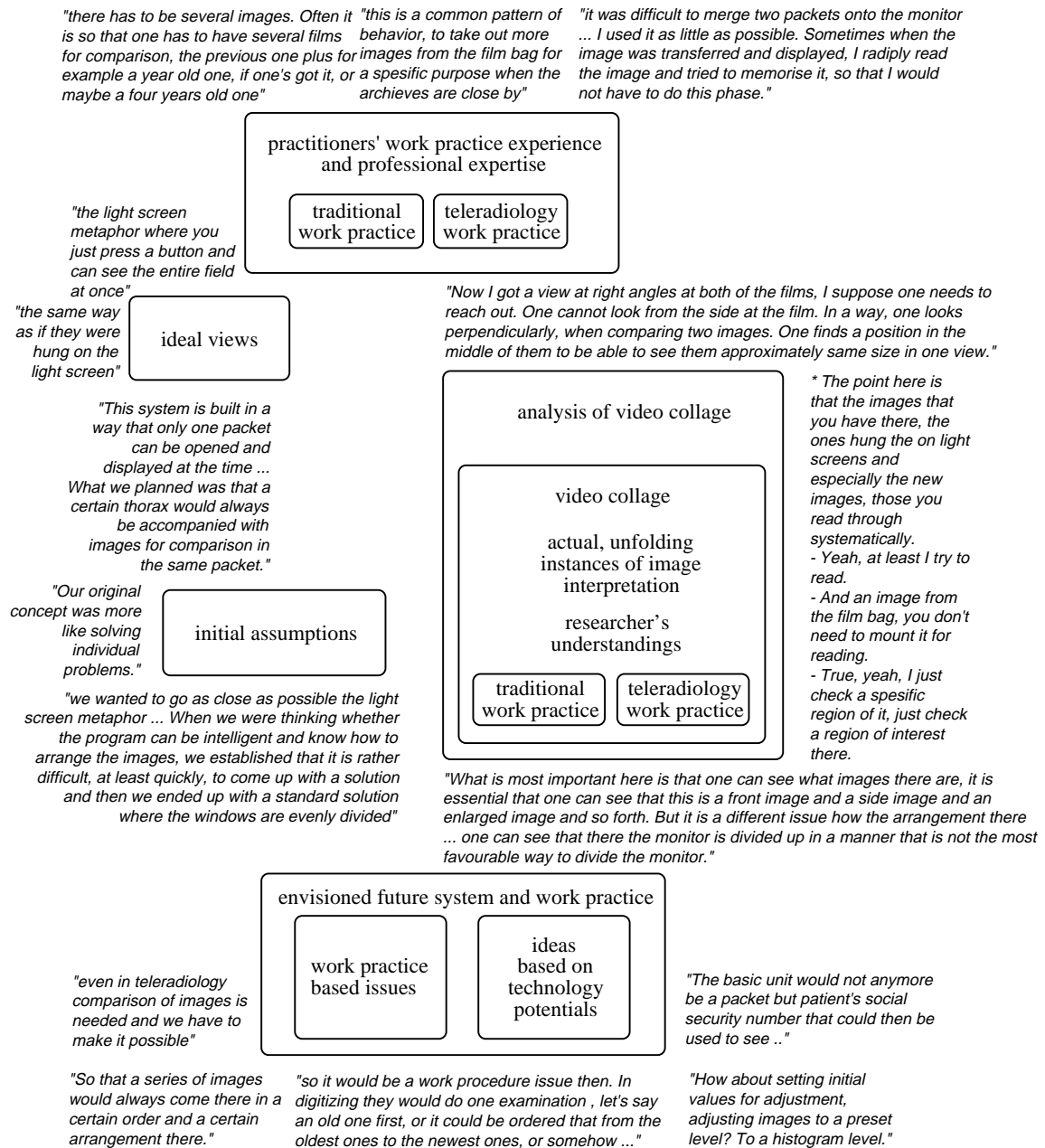


Figure 2. Various views voiced of image comparison

Ideal views scrutinised

The ideal views of image comparison become verbalised in references to the traditional work practice, in the light screen metaphor (Transcript 6, lines 9-10) and in the way images are hung on light screens (Transcript 6, lines 15-17). The ideal is based on what the radiologists are accustomed to in film-based work practice. During the past century of

radiology the material and technological environment, the work procedures, the network of support personnel etc. have been developed to create an optimal environment for the interpretation of films. The characterisations of the ideal stem from how the radiologists see themselves as representatives of their profession within the occupationally segregated and hierarchically stratified work communities. Radiologists' work is typically considered expert work requiring medical knowledge, professional expertise and also experience in form of seniority gained through the cases interpreted. The ideal implicitly includes but also conceals plenty of invisible and taken-for-granted aspects of work which provide for the everyday smooth running of the traditional work practice. It has been difficult for the radiologists to articulate these aspects that are so obvious to them to be unremarkable.

In the workshop some aspects of the ideal become visible for the first time as image comparison is explored through the analysis of actual instances of image interpretation. The radiologists discover how the obviously cognitively intensive image comparison carried out through *seeing* and learned through years of apprenticeship requires and is achieved through bodywork (Transcript 2, line 6). They also become aware of image articulation work that provides for the material resources and infrastructure for their image interpretation work which in traditional work practice is not their concern as it is carried out by a support occupation (Episode 5, Transcript 6).

Initial assumptions about teleradiology reconsidered

The design team consisting of radiologists and physicists from Oulu University Hospital, head personnel from Kuusamo Primary Health Care Center and designers from two hardware and software companies, had held initial assumptions about teleradiology. The original teleradiology concept based on general possibilities of telecommunications and digital imaging had been to provide technological support for clinicians' in solving individual problems with patients' radiology examinations over distance (Transcript 7, line 11). Hence the experimental system had been designed on the idea of packets of images being transferred and opened one at a time on teleradiologist's workstation (Transcript 4, line 2; Transcript 7, lines 1, 5). The accompanying assumption for the sending end included a procedure of scanning and sending all relevant images for image comparison (Transcript 4, lines 9-10; Transcript 7, lines 14-15). The ideal view of the layout of images on the teleradiologist's screen, expressed in the light screen metaphor, had been attempted in the initial design, but compromises had been made due to technological and resource restrictions (Transcript 6, lines 10-14).

Due to the discrepancies and problems in the clinical use of the teleradiology system and through the analysis of instances of teleradiology image interpretation, some of the initial understandings based on general expectations and potentials of digital imaging and teleradiology became challenged and reconsidered (especially in episodes 5 and 8A). Alternative design concepts based on actual teleradiology work practice were outlined. The idea of packets of images was abandoned in favour of having access to all images of a patient providing for initial overview and simultaneous image comparison of prearranged images (Transcript 6, lines 7, 17-24; Transcript 7, lines 12-13, 16-23).

Video collage of researcher's readings of work as shared object

The video collage of actual work practice was a way to offer back the fieldworker-researcher's readings of the radiology work to the workshop participants to be jointly worked on. The collage held the researcher's understanding of work practice as it was constructed through her choices in video-assisted fieldwork as well as in selecting and

editing the tapes. The fieldworker had formed her 'double' view during fieldwork as an *outsider within* the work communities having had a unique access and possibility to study the two co-existing technologically mediated ways of working. The video collage supports this aspect of the fieldworker's view in giving both an overall and synthesised view into teleradiology work practice in its entirety, yet also making visible workers' partial viewpoints from within the actual situated activities in locations of real clinical work. Sequences meaningful from the point of view of practice were chosen (a 'simple' and a 'complicated' case). Entire sessions of image interpretation in two technology environments were selected to show the work in its unfolding character, including both the routine smoothness and the problematic situations of everyday practices.

As shared object of activities the video collage serves as a medium and material for co-analysis and design dialogue in the workshop. The video collage with its sequential form of viewing structures to some extent the organisation and flow of discussion and activities in the workshops. Including both ways of working and starting the video collage with film-based image interpretation allowed the participants to establish a common ground of understandings about traditional work before proceeding to analysis, evaluation and envisionment of teleradiology. Nevertheless, as a rich medium video does not set strict limits. Rather, it invites for multivoiced evocations and interpretations as it renders the work practices both familiar and yet extraordinary. The participants recollect their lived experiences evoked by the video clips. The practitioner whose work is viewed immerses back in the event of doing the work. He recalls and recounts more situational information than can be seen on the tape. Other practitioners with evocations of their lived experiences provide for the richness of real life clinical work. At the same time the video collage acts as a mirror for the participants providing for analytic distance from the everyday point of view. Seeing one's own work in the video collage helps the workers in reflecting upon their daily activities from an outside perspective and in taking a more evaluative look at the system. The designers could see the technology they had developed in use in actual work for the first time. (For more on video collages, see Karasti 1997a).

Understandings based on analysis of actual unfolding activities

Collaborative activities start with and are grounded on viewing and analysing the activities and events of actual work represented in the video collage. During the workshop the participants learned to do analysis of the unfolding activities of work practice. They became more aware of and attentive to the richness of interactions, as well as the intrinsic details and temporal organisation of particular activities. The detailed level of analysis offered an opportunity to scrutinise the invisible routines or tacit aspects of work practices. The practitioners became aware of their own work in a new way through attaining analytic distance from the everyday doing of work. They were able to discover aspects of work that have gone unnoticed to them, i.e. discovering dynamic supplementation of films during image interpretation (episode 2E), body work inherent to image interpretation (episode 2B), and starting to articulate dispersed image articulation work (episode 5).

The practitioners readily relate the situated, particular instances of videotaped work activities to their lived experience of everyday work practices. They articulate what is important, common or typical in image interpretation from the point of view of their everyday routine clinical work (i.e. episodes 1, 2B, 2E). In formulating characterisations the practitioners give meanings to the particularities on the tape rather than just provide descriptive details of the observable activity. They have the professional expertise of practising radiologists and practical experience of clinical image interpretation *from*

within needed in articulating the means by which working practices arise and are constituted.

Throughout the workshop the participants were reminded of and could go back to the actual cases and particular instances of situated technologically mediated everyday work. Gradually the discussion became more and more grounded on actual work practice and system use, not some idealised and abstracted versions of it from without. The participants juxtaposed their (ideal) views with their observations of the videotaped instances of actual image interpretation work. They evaluated the success of the realisation of initial design concepts in the experimental system through analysing actual teleradiology system use situations. The participants were not anymore able to talk ideally about i.e. the light screen metaphor, or the general possibilities and overall potential of digital imaging and teleradiology, or the lessons learned from other clinical case studies. The work practice and design issues gravitated towards actual practices and design ideas became more accurately informed by practice.

Juxtaposing two co-existing technologically mediated work practices

The video collage brings into the workshop and makes visible for the participants the two co-existing technologically mediated work practices. The currently prominent, traditional way of radiology work practice is based on films. All radiology staff know the traditional way of working with films and related technologies as it has been prevalent for a hundred years since the time of Roentgen, and all practising radiologists have learned to interpret images this way. The teleradiology work practice based on digital imaging and computerisation has just emerged in relation to the experimental system use period. All participants have some assumptions about or expectations for teleradiology, but radiologist A is the only one having gained actual clinical experience with the experimental system.

The emphasis in viewing clips 1 and 2 is on traditional work practice. The participants collaboratively analyse film-based image interpretation work practice. Practitioners voice their lived experiences and endogenous categories through which they organise their work. Starting with clip 3 the experimental teleradiology work practice becomes more focal for collaborative activities and evaluation starts to intertwine with analysis. Radiologist A shares his lived experiences with the actual use of the experimental teleradiology system. Members of the design team provide for the initial design assumptions and considerations in the development of the experimental system.

The possibility to start with analysing the two existing work practices and forming characterisations and shared understandings of them allows the participants to base their subsequent activities on them. The participants readily juxtapose the two existing work practices already in analysing traditional work practice (i.e. episode 2B, line 3), but especially as they move on to sequences of teleradiology work. For example, in episode 3B all radiologists juxtapose and compare the traditional and the teleradiology work practices to point out discrepancies between them. Comparative considerations are put forward and taken into account in assessing the experimental system.

The possibility to juxtapose two existing work practices supports participants in expanding their thinking to horizons of different forms of technologically mediated work. They start seeing the change from traditional to teleradiology work practice and further to future work practice. Towards the end of the workshop the envisioned teleradiology system gets increased attention.

Images envisioned of future system and work practice

Throughout the workshop the participants co-construct images of the envisioned teleradiology system and work practice. In analysing traditional image interpretation requirements emerge, in evaluating the teleradiology system in use the problems identified frequently lead to suggestions for improvements for the system. In addition to the individual improvements or requirements evoked, the participants proceed to co-constructing images of the envisioned teleradiology system and related work. For example, in episode 5 in discussing the initial image display the joint work practice and system design issue is articulated from the radiologists' point of view as "series of images displayed in the same order and arrangement", in episode 8A in reconsidering initial design assumptions and reconstructing new design concepts for the future teleradiology system, and in episode 10B in weighting the need for specific image processing functions in the future system.

The specific design ideas and technology suggestions that arise from the potentials of digital imaging based teleradiology are evaluated in relation to clinical image interpretation work (i.e. Transcript 8, lines 18-27). The generation and justification of work practice based design issues of the future system greatly benefit from the collaboratively constructed understandings of radiology work practices (i.e. Transcript 8, lines 14-17) and especially from practitioners' experience and professional expertise (i.e. Transcript 5; Transcript 7, lines 16-21). The envisionment of images of the future teleradiology system and work practice becomes gravitated to actual work activities.

Practitioner experience and professional expertise appreciated

The radiologists' exclusive part of the radiological work practice is diagnostic interpretation of images. Hence their understanding of clinical image interpretation is unique. The radiologists' professional expertise is about seeing meanings in minute changes in shades of grey, about distinguishing the normal from the pathological, signal from noise, based on their extensive knowledge of human internal anatomy, physiology and pathology. The radiologists' professional expertise is partly based on practical experience. Seniority is achieved through 'reading cases' in the course of years and years of clinical work. All practising radiologists have gained their experience in film-based radiology as film has remained in the clinical radiology work although the pace of technological change with new computer-based imaging modalities has been quick since the 1970's.

The radiologists' views about their work are idealised (see above) but also used as powerful tool to think about change, to explore the relations between yesterday, today and tomorrow. As the teleradiology experiment was the very first time clinical image interpretation was carried out using solely digital images on monitors the radiologists had little experience in terms of making informed estimations about image interpretation based on digital imaging. In the workshop the radiologists could start relating the history and the future development of their work as they were able to juxtapose different technologically mediated image interpretation practices. This gave room for thinking about the ideal traditional practice as well as the initial teleradiology assumptions in a different light. The radiologists could relate their experiences with light screen interpretation to actual monitor interpretation of digital images. This made possible speculation about and envisionment of image interpretation in digital imaging based environment. Here the radiologists' professional expertise and practical experience was of indisputable value. Their understandings and views were necessarily professionally and contextually informed, and go beyond what could otherwise be established in the workshop context.

Discussion

Bridging work practice and collaborative system design was attempted through video-based multiparty interventions in relation to an experimental teleradiology system redesign. It was found that the workshop setting provided for a fruitful mixture of views and nurtured their interplay in the process of co-constructing shared understandings of technologically mediated work practice for system design.

The workshop created an environment where the practitioners had an opportunity to gain *analytic distance* to their everyday work through video analysis. In the workshop the practitioners explored the not-easily-articulable tacit knowledge which is manifest in the routine practices that became visible and approachable through the detailed video-based analysis. Video-based analysis of work where practitioners participate in analysing their own work is by nature different from Interaction Analysis (Jordan and Henderson 1994) performed by researchers only. The practitioners were able to give meanings to the observable activities in the video. The shared understandings of work practice and technology use as well as design issues shaped over the course of the workshop are contingent and historical as the practitioners have the abilities to bring in to the analysis of videotaped work their various views of work practices, their lived experience and professional expertise.

Analytic distance provides the practitioners with a different kind of opportunity for learning about their work and its technological support than 'mutual learning', promoted in the PD approaches. In PD the user participants are brought in to provide for insights of work practice and context with their skill and expertise from the work (cf. Schuler & Namioka 1993, Greenbaum & Kyng 1991). In the design process the participants engage in mutual learning (cf. Ehn 1993). Designers are to learn about practitioners' work. The workers are to learn about the possibilities of new computer support to be able to evaluate the opportunities the computer systems could provide for them in their work. The focus on users learning is mainly on information technology skills, whereas learning about and understanding work is implicit. (Favorin 1994)

Grounding on analysis of unfolding activities and events of actual work and being constantly reminded of them by the video collage gradually *made participants' activities gravitate towards work practice*. The analysis of work carried out in the workshop comes close to the video-based Interaction Analysis in the Workplace, WIAL (Cefkin & Jordan 1994) and the Change Laboratory of Developmental Work Research (Engeström, Virkkunen et al. 1996) which have not been used in system design context. In our case, however, there was also a distinct design interest involved, intention to evaluate the experimental system and to continue to envisioning a future system. The entire workshop process as well as the design considerations and implications became informed by actual work practices. New appreciation about what is important to attend to in design was gained in the workshop. In the course of the workshop the participants came to recognise what the issues were, not only about the teleradiology design but about what was important to attend to in the analysis, evaluation and redesign.

The purported disciplinary differences of ethnography and design (i.e. Bader & Nyce 1998, Grudin & Grinter 1995, Button & Dourish 1996) become less consequential as participants with different backgrounds, views and outlooks collaboratively engage in constructing understandings of technology use in work practice and in formulating appropriate design implications (cf. Blomberg & Trigg 1997).

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