Role, Identity and Work: Extending the design and development agenda

by

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Linköping 2006
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Acknowledgements

There have been quite a lot of twists and turns during this work and during the time there have also been a lot of people involved and supporting this work, in some way or another.

I owe gratitude to Hans Marmolin for starting this project up (even if things might not have turned out the way that we discussed during the early years).

One person that also has been involved from the beginning, and that has stayed to see the end, is Sture Hägglund. For the support, advices and all the practical issues that have been during the way I am grateful.

For the way that this work has finally turned out, I would like to thank Kosta Economou who have listen, read and made things happen when they really needed to. Which leads me to Anders Ynnerman and Per Kjäll, who I thank for believing in my fuzzy ideas and allowing me to test them.

I am also very grateful for having the honor to work with Jim Nyce and Toomas Timpka. Without them the fuzzy ideas that I had would not have become understandable science. It has been a real pleasure working with you both.

During these years I have also been fortune with good colleagues. In particular I would like to thank Aseel Berglund for sharing the hardest time, you are a good friend. There a lot of interesting people at IDA (and previously at Nokia) that has been very fun and interesting to share workspace with, in particular I would like to mention the LIBLAB, even not a full member I still enjoy the time spent with Fredrik Arvidsson, Jörgen Skågeby and Andreas Björklind.

The work, travels and discussions with Magnus Ingmarsson have made the work a lot easier. The cooperation (and travels... and discussions...) with Jonas Lundberg has also been both fun and interesting. And the
afternoon talks with Anne Galloway have made the long days shorter and easier to stand.

Thru numerous of lunches that has been both relaxing and really fun I have enjoyed the company of Larol, Lawes, Chaso and Guseb.

I also appreciate the work with Gränssnittsakademin (Rikard, Andreas and Göran) and UserLane (Thomas) for making academic theory come to practical use.

Thanks to Vanessa Deutsch for providing the cover art.

Robert and Erik, the best friends one could ask for.

My family: Mum, Dad, Fredrik, Johan and Jenny for always being there. Especially thanks to the Lindvall clan for their hospitality and support.

Finally and most importantly my gratitude goes to my beloved wife, Akhlas. Without your support nothing of this would have been possible.
I used to think that the day would never come/
I’d see delight in the shade of the morning sun
/ My morning sun is the drug that brings me near /
To the childhood I lost, replaced by fear /
I used to think that the day would never come /
That my life would depend on the morning sun... B. Sumner

First time I sat in front of a Macintosh Classic II was actually the starting point for getting interested in how to interact with machines. My first thought was: This is how it is supposed to be! I had used computers before, some just for fun (Commodore VIC-20, Commodore 64) and others to actually do school related work (PCs with Dos and Windows), but I never really liked them. For me it was a gap that was too big between the use and the task.

For a long time the space between the user and the technology has been referred to as the “user interface”. One interesting aspect of using this label is that the perspective is really from the machine (or technology). This means that it is the user who is the unknown, and the technology that is the known, i.e. it is user interface, not computer interface).

In the beginning of computer science, there were many interfaces that could be referred to, and the one that was in contact with the user then simply became the user interface. [Grundin, 1990] Even if this kind of historical perspective can make the use of the concept “user interface” appear quite safe, it still reflects the experience that I had before encountering the Classic II. The user interface was the technology’s perspective of interaction; it was technology centered, not user-centered.

I didn’t relate to this knowledge as until I started to study at the university. When I started at the university I could not decide if I wanted
to focus on technology or social sciences. My undergraduate courses thereby became a mixture of courses in information and media science, and courses oriented towards social sciences, like cognitive psychology and behavioral science. These choices reflected an interest in how people act and how technology can be used. In fact, the area where the two meets became the most fascinating to me and often was this area referred to as the interface between the user and the technology.

Later, with more experience, I found out that it was often not just the interface that was the obstacle when it came to users and the use of technology. Or at least, the interface simply represented the surface of the technology. There was something more that got some people to accept new technology from the beginning and others to never accept new technology. This differed between users, machines and tasks.

In 2000 I started at Nokia Home Communications in Linköping as an industrial PhD student. The idea was to work with intelligent home devices and aspects such as integrity and personalized applications. The work at Nokia was very fruitful, not only from an academic point of view, but also from a personal perspective. The atmosphere there and the work done during the time at Nokia has been encouraging in the way that it made me reflect on issues such as: What is needed to make an application attractive for the user and what can we do about the interface between applications and users. In fact, the very issue of what is an interface was considered there at length.
So, what is an interface? One definitions is to be found from the philosophy behind the interface in my first encouraging encounter with computers:

*An interface is not merely a visual display- in fact, it’s possible to have an interface with no visual display at all. A human interface is the sum of all communication between the computer and the user. It’s what presents information to the user and accepts information from the user. It’s what actually puts the computer’s power into the user’s hands.*

*Human Interface Guidelines page xi [Apple Computer Inc. 1987]*

This definition includes aspects that extend far beyond the interfaces that are generally connected to personal computers. The key phrase here is “the sum of ALL communication between the computer and the user”. The communicational part is not only from the perspective of the user; this definition states that the technologies, in these case computers, are allowed to communicate. This could be considered as a first step for the technology to become social, and take social space.

A central motivation for me doing this kind of work has been a curiosity of why some people (users) adopt technology and others tend not to. This has been, as mentioned above, an interest since I saw how presentation (in the form of a Graphical User Interface) could change the use, the attitudes towards and the function of technology. During my undergraduate studies I have looked at this subject from different perspectives, from Informatics and Information Behavior to Cognitive Psychology. When I finally started at Nokia and started to work on the subject “for real”, the interest was directed towards the home environment and users in relaxed leisure environments. The most interesting aspect here was the complexity of the users; given the market that we aimed at was broad and very varied. However, Nokia closed down their Linköping activity and the focus was shifted, partly because the actual platform that had been my base of research (the MediaTerminal™) was discontinued, but also because my interest started to move towards new areas such as professional situation where complex forms of work were done.
From an academically point of view, the reading of *Life on the screen* by Sherry Turkle [Turkle, 1996] during my undergraduate studies has been one of the most important sources of inspiration, both from an analytical and methodological point of view. For me this was the introduction to research that was built on observation and participation with the objects of study and it also convinced me that to be able to say anything about actual technology use, one has to look at actual users. This would create a deeper understanding not only of the user and the task, but the technology itself. Turkle also presented a point of view where the technology would, and could, take social space, i.e. an artifact has the possibility to be a social co-actor and must be allowed to be that. As part of the sum of communication between the technology and the user, the role of technology as a social co-actor is very important and it also makes the user adopt a social role, even if the technology is the only other actor available.
1. Introduction

People use contact with technology to keep in touch with their times, to discover “what’s important”. [Sherry Turkle, 1999]

Technology use often reflects and influences the social context in which the devices operate. [Barley, 1986] Also, the interaction with technology, as any interaction, can be seen as fundamentally social. [Reeves, Nass, 1996] This relation between technology and the social context is visible in situations where technology and users are to some degree specialized, where both task and social structure is influenced and influences the use of technology (compare to [Shackel, 2000] and the discussion of enlarging HCI (human-computer interaction) to HSI (human-system integration). Barley has for example looked at technologies introduced into radiological work and how these technologies effect both task and the skills possessed by the users. [Barley, 1990] This relation between the technology and the social structure that create the context of use has also been discussed in the design-literature especially in the tradition of Scandinavian Design [Kyng, 1993] or Contextual Design [Beyer and 1999]. However, this link between role, work and technology has not received all the attention it deserves. This relation between technology and the social structure has also been an important part in learning general interaction design. [e.g. Preece et al, 2002] However, the question of the importance of the users’ identity in this context has only been partly investigated.

In professions with strong professional identities, like surgeons or journalists, identity is likely not only to effect the tasks performed, but also the interaction with the technology used to solve the tasks. Also, in this context, the technology will then effect the users identity in reverse.
The interaction with the technology will continuously create user experiences, and thereby also develop the user history and the user identity. It becomes a mutual relation where the identity and the use of technology will develop together.

This thesis is about this relationship between advanced technology and professional users, and more specifically how the users see themselves, their tasks and their tool in their professional setting. It explores how identity and role affects the use of advanced technology. This is contextualized into two different work domains: the clinical field of neurosurgery and the journalistic field.

In short, the aim of this thesis is to study:

- The impact of the professional identities and the roles in the use of advanced technology

More specifically, the questions addressed in the papers included in this thesis are these:

- Paper 1: How does the identities and roles carried by media producers, effect the results reported in a participatory design oriented study with focus on user requirements

- Paper 2: What impact does the role and identity of clinicians have when defining work and task, especially in relation to safety

- Paper 3: What do designers and developers need to take into account regarding roles and identity when creating support tools for clinicians

- Paper 4: What issues do designers and developers need to address regarding role and identity when creating clinical visualization tools

- Paper 5: Does the use of 3D-visualisation and haptic technology "make sense", given how GammaKnife users define themselves?
The major focus in this thesis is on the clinical setting of neurosurgery, and the technology use represented by the neurosurgeons and medical physicists, the technology here being the Leksell GammaKnife (paper 2, 3, 4 and 5). This perspective involves not only two quite strong professional identities; it also involves a highly specialized setting with very advanced technology.

The journalistic identity is also quite complex, and the journalistic environment is also a setting by the recent and fast development of technology. The introduction of new media (new media defined as when all parts of the process of producing media is done on computers) have made the journalistic setting a more technological than it was just a couple of years ago. It has also changed the way that journalists work. [Manovich, 2001]

To see what kind of impact these technologies have on the users identities and roles, this thesis looks upon different stages in the development and design of technology in these two settings. These settings and studies are further described in Introduction to studies.

1.1. Theoretical background

Complex technologies infiltrate everyday life. This is visible both in the technology that are directed towards home use, but also in the professional segment. The need for making this technology usable is, according to Shneiderman, dependent on three different challenges: Technology variety, user diversity and gaps in user knowledge. [Shneiderman, 2000] The focus on this thesis is on the users diversity, and more specifically user diversity using common technology, performing similar tasks, in professional settings. The use of complex technology in professional settings does not only increase the demands of the knowledge from the users; it is likely that it also increases the complexity of machine-human interaction. In other words, complex technology demands knowledge from the user that makes the actions taken by the technology comprehensible (even if not fully
understandable) by its users. Also, this makes the interaction with the technology complex in the sense that every step taken in the interaction will not only demand knowledge about the actual action, but also how this complex action is represented and to some level implemented within the technology. To make this even more complex, the social setting is also a dimension within the interaction. In an organization where both the technology and its users are highly specialized, the organization will effect the use of the technology and, equally important, the view the user has on this technology.

The dependency between the organization and the technology means that the technology occupies social space; it is not only that the users of technology use the technology as a social tool and cognitive support; the actual technology also has a social space. What this means is that technology have an important role in the structure of the organization and social interaction within the organization. As Nass et al points out, it does not mean that users consider technology (or as in the specific case with Nass computers) as humans, instead users apply social rules and roles when interacting with technology [Nass et al 1994].

This is what Turkle meant when she talked about technology as a social mediator. The computer oriented communication made the user take different roles and use different identities depending on the context where s/he was acting. [Turkle, 1996] Even if the actual computer in this case did not take the individual role of a social companion, it allows its user to take a different role, roles that might not have been possible without the computer-mediated communication, because the anonymity of the computer mediated communication. The identity-shifts that are described (for instance in relation to MUDs) by Turkle are not only made possible by the use of the computer, these identities would not have existed if it were not for the technology used. There is, however, a difference between the use of different identities in communication with other individuals (even if sometimes these
individuals turned out to be Bots), and to consider the computer and technology itself as a social co-actor.

The presence of technology and computers effect on the social surrounding has been discussed by e.g. Kling, who points out the difficulties of having an exact identification of these effects [Kling, 1991]. That is not to say that they are not there, but it is often hard to identify exactly what kind of consequences the technology has on the organization. Perhaps the research on how to increase the social presence of technology by using cues of human properties, e.g. [Min Lee, Nass, 2003] has pointed out what some of the consequences are. This literature also illustrates how and under what circumstances technology can mediate identity. Before exploring the technology as an independent social co-actor, there is a need to look into how we interact with the rest of our surroundings. The need to see technology use as something more than just a straight human-computer interaction (HCI) has been discussed for a fairly long time. The introduction of political views of design in the participatory (or Scandinavian) design and cooperative design [e.g. Bødker et al, 1988; Ehn, 1992; Kyng, 1994], represents one such an attempt to expand the field of HCI and include the issues and problems characteristic of the modern workspace. Research that follows this tradition can be found in studies of medical appliances [Timpka et al, 1995] and studying journalistic work [Lundberg, 2004].

To extend HCI beyond "simple" man-machine interaction has meant that researchers have looked to more broadly define what context are in respect these interactions. This can be seen in example the work with situated cognition [Suchman, 1987], distributed cognition [Hutchins, 1995] and shared cognition (as described by [Dillenbourg et al 1995]). In the case of distributed cognition and its relation to situation awareness (SA), the importance of the social context and not just the physical has been discussed by [Artman and Garbis, 1998].
Why there has been an interest in this area of research is that the surrounding environment, including colleagues, will influence the interaction in such a way that doing design without taking the surrounding into account would not be fruitful. The implications this argument has been explored at length by those interested in contextual design [Beyer, Holtzblatt, 1999].

1.1.1. The professional user

As mentioned in the Preface, the user interface was the interface that was in direct contact with the end-user, compared to other more technological interfaces that were involved when creating computers. The problem that Grundin touches upon is that often the users are considered by the HCI researchers as novice or expert users depending on their technology skill, not on their professional knowledge [Grundin, 1990]. That is, an expert user could be a computer novice since s/he could be an expert on his or her field, but have limited experience with computers or technology. It can also be that the user is a so-called “accidental user” [Marsden and Hollnagel, 1996], i.e. a user that is forced to use technology because there are no alternatives; the technology has to be used to perform necessary work tasks.

Today it is likely that there are fewer computer novices using advanced technology in professional settings than in 1990, but we can still argue that many accidental users exist. However, it is important to acknowledge the expertise level that the users in this thesis have, they are professionals (and experts) within their field, still they are not computer scientists or interaction designers. In a way they are accidental users since their knowledge relates to the task not to the computer use or to the interface. Also, the knowledge that they carry into the work setting is a highly specialized knowledge and experience. The technology is there to support this professional user. In a way the technology has become the interface between the user and his or her work [Bødker, 1990].
In a professional setting, users create, and are introduced to, a common professional language within the setting. This language can include a shared set of understandings one is engaged in and this can be visual, physical and verbal form.

Alac and Hutchins have explored the relations between the visual understanding and physical expressions in clinical situations and how the action is perceived as part of and linked to cognition. [Alac and Hutchins, 2004] Earlier on, Hutchins has shown how the cognitive processes are not all located inside the user’s head, but the surrounding environment, which can play an important part in cognitive processes [Hutchins, 1995]. As Alac and Hutchins points out, it is not possible to give a complete description of what happens in the user’s head with the technology and methodology that we have available today [Alac and Hutchins 2004], and this might never be possible to do. However, depending on the scope of a thesis (and this not being a thesis in psychology) the exact knowledge about what is happening in the heads of users might not be that interesting or even that relevant in reference to issues and technology and usability. How the user experiences the situation is of more interest than what “goes on” in the brain. Much of the usability is about the user experience and if a certain technology is usable for the user. Part of the usability is then to create acceptable, appropriate languages that link users to their tools. Graves and Nyce have pointed at the problems this issue raises when introducing visualization technology in a clinical setting, and more specifically in a neurosurgical setting [Graves and Nyce, 1992]. The problem they discuss is related to how to express knowledge using visualization technology, and the difference between “academic medical knowledge and the needs and requirements of ‘clinical practice’” [page 147, Graves and Nyce, 1992]. The lack of understanding that the developers have for this difference make the tools created using, and depending upon, a language and a set of understandings not necessarily understood by its users. To create a common set of understandings (a common language if you will)
between developers and practitioners, Graves and Nyce argue for an awareness of these differences from the very first day of the design development (and preferably by involving social science and social scientists).

A common professional language might, however, not be that easy to identify. Linell et al show how the use of verbal and physical language changes in a professional clinical context [Linell et al 2002]. How the language changes depends on whom the message is directed to, towards colleague vs. towards patients. Further it can vary according to perceptions of status (with colleagues) and risk (with patients). By using different types of language the clinical staff can empathize or suppress a specific subject. That is, they can create an understanding within the patient for the situation as well as for the level of seriousness.

1.1.2. The concept of professional identity

In short, the identity is the way in which we define who we are. Wenger talks about Identity as a negotiated experience, a community membership, learning trajectory, nexus or multilibration or as the relation between the local and the global. [Wenger, 1998] In these definitions the identity is, first, a notion that orientates a person in relation to others. Second she points out that the identity also has to be regarded from the individual's own individual perspective. This suggests that to be able to analyze identity, data collection and analysis has to be preformed in (and taking into account) social settings. In the work presented here, the identity has been found to have a strong impact on the use and understanding of the professional work setting and the technology involved therein.

Both identity and role are contextualized in relation to self and others. Both in a way represent social aspects of a person, even if their presence does not require a social setting "to be played out".
In respect to role and identity, the community can be quite important, and is defined by Wenger in this way:

*Community: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.* [Wenger, p 5]

Wenger’s definition of communities makes it possible that a group can consist of members that are connected to several communities, more or less independent of that particular group. To give an example, one can define the community of practitioners (which is the kind of communities that Wenger focuses on) in a certain area as being a community, such as for instance neurosurgeons, physicists or journalists. These different communities may be linked by a shared notion of profession but this can be independent of their work site. So, in a surgical situation the group involved in the surgery might be members of different communities. These communities existence might be independent of the existence of this specific group. The surgeon, the nurse are all part of the “surgery community”, the “nurse community” and whether this particular surgery would take place or not, these other communities would still exist. According to the definition given by Wenger, there is a possibility that every individual might be a member of several communities. In the example above, the nurse and the surgeon might also consider themselves as members of the community of “health care workers”. There is also a possibility to be part of communities that are not connected to their specific profession, even if not within the scope of Wenger’s Communities of Practice. For example the nurse might be a member of a goth-community and the surgery might be consider himself as a member of a house-community, where the communities reflect an interest in a specific music genre. Of course some of these communities, ones closer to work tasks, are more important than the others to understand in relation to design and development of tools and applications.

1.1.2.1. Role

Within a group, different members have different roles. The roles describe and prescribe the behavior of the members of the group
[Hogg, Vaughan, 1995]. In this way, the roles are closely connected to the task that each member of the group has assigned to them. Roles help synchronize (and sometimes optimize) actions performed by the group. This is not to say that one person cannot have several roles within the group, and several members in a group share the same role. [Hogg, Vaughan, 1995] Note the difference here between the task-oriented roles, as described here, and the “theater” role as Goffman [1977] describes it. The role as Goffman describes it is more related to the view of identity presented further down.

1.1.2.2. Identity
An identity is the way that we see ourselves; in a way it is our self-image. We can have several identities, and we can maintain them all simultaneously. As mentioned above, this can be related to Goffman's definition of roles: Goffman defines roles as the acts that we play in social relations to others [Goffman, 1977]. The identity we each hold would then be the supposed act that we “play” when we are looking at ourselves from a perspective. However, this identity reflects the social context we find ourselves in whether this be work or more informal, private in social settings. We use our identities to create meaning in our social surroundings, and to affiliate with others in communities or groups. Identity then becomes the bridge between the social and the individual [Wenger, 1998].

Within a working situation identity takes on specific characteristics. This, however, does not mean that the working situation is responsible for more or less complex identities compared to other situations. Instead it means that the identities created in the work situation are closely connected to that specific work situation and might not exist outside of it. This working identity may enable individuals users to see the problems and solutions in different ways according to their identities, for example as scientists, operators or journalists etc in particular work contexts. Decisions made and actions taken will reflect this professional identity. In short scientists will make decisions upon assumptions that correspond to his or her identity as a scientist. The
same way goes for an operator, nurse or journalist and so on. Since every action taken reflects particular workplace identities, both task and solution and how both are defined and enacted, it will be to some extent dependent on the identities at hand. Of course given this, how work itself is defined will to large extent reflect how identity is enacted in a particular context (Figure 1).

We can illustrate this by looking at neurosurgeons. One characteristic we can identify regarding the identities neurosurgeons "take" is a desire to be scientific. The definition of what it means to be scientific is perhaps best elaborated in the concept of evidence-based medicine, where the combination of "clinical expertise and external clinical evidence from systematic research" [Sackett et al, 1996] is ideally the foundation on which to make clinical decisions. The way that the neurosurgeon then performs the neurosurgery will reflect what science has to say and this leads to that definition of "good" neurosurgery which in turn reflects both what identity "is" in this context and how that identity is manifested in the act of neurosurgery.

1.1.2.3. The relations between role and identity
As mentioned above, a work group consists of members with different roles that can be related to their task. The roles often enable the efficiency of the group. Each role also has status relations to the other roles within the group. Even if the roles in the group are distributed to the members of the group according to task and skill, this does not mean that the task and skill are interwoven (or can be equated) with the
structure of the group. As Barley points out both task and skill are, at least from an analytical point of view, separated from social relations.

Tasks refer to instrumental actions, whereas skills usually refer to abilities. [Barley, p 67 1990]

Further, Barley concludes that the concepts of task and skill are not sufficient for understanding how the technologies used in an organization and the organization itself "works": one has to take the structure of the organization into account.

Hence, in a situation where technology has a place in the social order, and thereby affects the social order in which it is used, the instrumental actions or the abilities within the user groups can be of secondary analytical interest. The relation to the technology and how the technology relates to the user identity can be more than the actual task to carried out and the required skill to perform the task.

1.1.2.4. Attitudes

It has been argued that one useful way of predicting behavior and decisions in relation to technology (and in particular to computers) would be to use attitudes towards the technology [Shaft et al, 2004]. When asked to associate to the concept of technology, people tend to associate to a specific technology [Daamen et al. 1990]. Also, when teaching computer use, Strong and Neubauer argue for the importance of students having a positive attitude towards computers so that they are open to computer use. [Strong and Neubauer, 2001] Attitudes, being one part of the identity together with the personal history, are responsible for associated pre-conceptions of the social surroundings [Greenwald et al, 2002]. In order to handle and structure the surroundings economically we use preconceptions, formed by previous experience. In a new situation, we relate to our previous experience and the belief of the outcome of the situation reflects the set of attitudes one carries with one i.e., individual history will inform how we interact with new situations.
The attitude is weighted with risks and benefits, and often risk can be the dominant part [Sjöberg, 2002]. If a concept or situation is considered as risky, threatening the personal identity, the individual will develop a negative attitude towards that specific situation or concept. Equally, if the situation is considered from previous experience to be beneficial the attitude towards that specific situation will be considered as positive.

If then the positive attitude is in one way or another confirmed the situation becomes (is perceived by the individual as) trustworthy. A person can be convinced or persuaded to regard a particular situation as trustworthy and this is even more likely to occur when one has already a positive attitude regarding that situation.

1.1.2.4.1. Trust, Risk and Benefit

Depending on task, context and the identity of the person exposed to a situation, for example a clinical intervention, each specific situation can be judged differently. Each situation can be judged in relation to trust, risks and benefits. When a situation is evaluated and considered as beneficial for the person, he or she will find the situation trustworthy. Shapiro uses this definition of trust:

... a social relationship in which principals- for whatever reason or state of mind- invest resources, authority, or responsibility in another to act on their behalf for some uncertain future return. [Shapiro, p 626, A Social Control of Impersonal Trust]

This sociological definition of trust also involves a time or history; trust could also be related to either the past (as experience) or the future (related to previous experience). Even if Shapiro does not talk explicitly of the risk connected to trust, it is possible to see this connection. Often invested prior resources, authority or responsibility have to be overcome to gain the trust. Risk is defined in the Oxford American Dictionary as “a situation involving exposure to danger”, or it can also be seen as “the possibility that something unpleasant or unwelcome will happen” [Oxford, 2005]. This definition highlights the negative aspects of risk. Linell et al uses three points when talking about risks in the health care consultation discourses [Linell et al. 2002]. First is the
difference between how the “practitioners of science and people in the everyday mundane world” relate to the concept of risk (and more specifically how they talk about risk) [Linell et al. 2002, p 196]. The second point is how to transform the knowledge of risk as the professional sees it, to an understandable message to the lay people. The third point is when the information gets to the person and the person reach some kind of understanding about what risk means to him or her in a particular context. One result can be that the person is likely to feel uncomfortable and might even develop symptoms as a consequence from knowing about the risk. These communication-oriented risk situations gives an indication of how the same situation will be experienced differently, by different actors involved depending on their understanding of the situation.

In this thesis, the focus is on the professional situation, and how the people referred to as “practitioners of science” by Linell et al, interact with technology. The risks discussed here is then primary directed towards the practitioners and the working situation, and this does not necessary directly connect to the health status of the patient [Dinka et al 2005:1]. However, the relation practitioners have to the patients, and how to explain for the patient their condition is a subject that has an impact on how these practitioners use the technology at hand.

The subject of trust is also discussed in other disciplines, where trust and risk are linked more often together, for example within the literature of management. Sheppard and Sherman connect the issue of trust to the concept of risk in their Grammar Of Trust [Sheppard, Sherman, 1998]. They describe trustworthiness as a relation between level of dependence (shallow/deep and dependence/interdependence) and risks. Even if this grammar is derived from research on management relations, this grammar can be very useful when we turn to technology interaction. Sheppard and Sherman describe relationships as involving risks, and trust, as they understand the term, is to accept the risks involved given the type of dependency involved [Sheppard and Sherman, P. 422].
Benefit could be seen as the counterpoint to risk. Risk and benefit would then be the two extremes on the same axis. To overcome a risk, the alternative or choice has to be regarded as beneficial "enough". If a choice (or object) is beneficial in the sense that it validates positively, at some level, the personal identity, it is very likely that the individual will develop a positive attitude towards that specific choice (or object). The object of trust can be other people or technology.

1.1.2.5. Technology as a social actor

As mentioned above, technology has a possibility to take the place of a social action in an organization or in a group. This does not mean that the active role that the technology takes will make the user passive. The social space is built on “intra-action” between the user and the technology (see [Suchman, 2000]). The reason for the technology to be able to take this social space is not only because the relation to the users' identity. The use of technology is at several levels very social, partly as shown in the interaction [Nass et al 1994, Min Lee 2003]. This issue of "replacement" in social space has previously been discussed and related to applied practice [Marcus, 2003] (for a discussion about humane interfaces see also [Raskins, 2000]). Technologies long used in an organization will eventually be part of that organization. If there was a possibility to introduce a new system to an organization, independent of what the organization has now, it is likely that the new system would be more efficient. However, since the old system is invested in, like the data stored, the trained personal, staff relation to the system and so on, the old system is part of the organization and the organizational structure. [Star, 1989] This entire "residue" builds into the organization skepticism and resistance towards new solutions and new technology. It also makes it more difficult for any new technology or system solutions to replace the social space that the old technology used to occupy.
1.1.3. Visualization

Information visualization has traditionally been used to understand and identify complex phenomenon. It is however important to relate new findings (and current research) within the field of information visualization to real situations and make them applicable to real problems [Plaisant, 2004]. The visualization of interest here, primary used in clinical work, should not be confused with the information visualization where the visualization often focuses on abstract information instead of mapping the physical world [Gershon et al, 1998]. In the clinical setting of GammaKnife use, information visualization has the goal of delivering a picture or a representation that approximates as closely as possible practicable reality. For example MRI pictures do represent the brain if the brain were cut in to very small slices. Even so, the MRI and 3D-visualization of the brain is still representations and interpretations of the real world that have to be analyzed by its users. Since the representation is an additional step from the "real object", one has to take into account the distance that exists, whatever that may be, between the “real objects” and those on the screen. This kind of visual information navigation is, as described by Benyon, as an interaction of different levels viewpoints [Benyon, 1998]. Here, the user shifts between the mental mode of task, orientation and functions and the operational mode on the screen shifting focus from the object to menus to task.

Good HCI-oriented interaction with information visualization (what appears on the screen) is important, but it is not enough. There is also a need for knowledge about information interaction as well as new visual interfaces. To create useable information visualization, there is a need to go beyond traditional HCI issues, concerns and "remedies" [Gershon et al 1998].

1.1.3.1. Medical visualization

The specific field of medical visualization is different in several aspects compared to traditional informational visualization. This has much to do
with how the information is to be used, but also with the potential consequences of misinterpreting the information. Imielinska and Molholt hint at this difference when talking about biomedical imagining as clinically centered, as opposed to medical imaging projects with an engineering-centered approach. [Imielinska and Molholt, 2005]

What usability regarding applications and devices will depend on is how users see their own work. This is what the distinction between clinically centered or engineering centered suggests. In fact, it could be a starting point for discussions of "fit" when it comes to the implementation and development of new visualization technologies.

1.1.3.2. Haptic and 3-dimensional representation

One technology that has gained recent attention, both in the field of information visualization, and within the field of medical visualization, is the use of 3D representation and haptic interaction. In medicine, we can now use technologies such as PHANToM technology in areas such as implant creation [Scharver et al, 2004] and training situations [Williams et al, 2004] etc. Recent development in technology, both hardware and software, has made the use of 3D technology cheaper and more available. However, as pointed out by Gershon et al, it is not self-evident why and when the use of 3D is better and more effective than 2D. [Gershon et al, 1998] The understanding of when the use of 3D is better suited for a certain application is to be decided empirically on a case-to-case basis.

The use of 3D representations also demands different type of user interactions compared to 2D representations, partly because the common graphical interaction devices (GID) that are used today in 3D representations were developed with a 2D representation in mind. The 2D representation is one where the interaction cannot be as in “real life”. The 3D representation can make the interaction more similar to a “real life” situation, since the 3D objects have more real life properties, especially if haptic forces are implemented. In fact, it is argued that 3D visualization and haptics have the possibility to deliver a sensation so
close to reality that it will be used as its equivalent (as with flight simulators and diagnosis through touch) in several medical areas [Williams et al 2004].

1.2. Introduction to the studies

This thesis is based on three separate, but related studies. To frame the general discussion and conclusions, the different studies, their objectives and results are summarized below.

1.2.1. The media creation tool project

The journalism study was part of a large EC-founded project called the Electronic Newspaper Initiative [ELIN, 2005]. The ELIN project aimed at creating a news publishing system prototype for future news management and it involved partners from Sweden, France, Germany, and Spain. The study presented here was part of research effort devoted to eliciting of user requirements for the ELIN prototype and involved different media actors. Participatory design oriented workshops were formed with representatives from a newspaper and from a political group. The political group was used to represent groups outside the traditional media scene who shared journalists’ interest in message creation and diffusion. (It was in a way a comparison group, a B to journalist’s A). The study involved workshops with the different user groups; these workshops were then transcribed and analyzed.

1.2.2. The Leksell GammaKnife project

The work with the GammaKnife started as project that was to bring haptic and 3D visualization to the GammaKnife (reported in [Dinka et al, 2005:3]). Research carried out before (and in preparation for) this project was an usability study of the existing system. The first study involved interviews and observations with experienced GammaKnife users during GammaKnife practice. Two main groups of users were studies, neurosurgeons and physicists. Their experience and the way
that they used and talked about the technology showed significant differences, even if they performed ostentively similar work and tasks. The work and findings from the initial studies was incorporated into the later haptic/3D-study.

1.3. Summary of the Studies

The impact of professional identity and the work oriented roles had in the use of advanced technologies by media creators, medical physicists and neurosurgeons in their use of advanced technology is reported in the five papers that are part of this thesis.

1.3.1.1. Identity and Role – a qualitative case study of cooperative scenario building


In this study we found that users participating in the design process will form the process from their professional roles and their user identity (how they see themselves). In order to realize the full potential of cooperative design user identity in general and in this case their attitudes towards technology in particular, needs to be incorporated into the design process. This case study consists of participatory design sessions with two different organizations, in the context of a media production tool development project [ELIN, 2005]. Facilitator skills, and workshop interventions to accommodate different attitudes and to take them into account in design are discussed. Furthermore, we have found that attitudes can affect subsequent implementations of a technical system, and that knowledge about stakeholder identity can be useful when it came to additional design activities and for planning system implementation.
1.3.1.2. GammaKnife surgery: Safety and the identity of users.


The work with the Leksell GammaKnife started as a single study. The project did evolve over time and its scope and models employed in the research expanded. In the first study presented we investigated safety-related usability issues of the Leksell GammaKnife. We were interested in which criteria are important for users if a system’s usability and safety is to be improved.

The main finding was that the user’s identity or professional background has a significant impact both on how he or she views his or her role in the clinical setting, and on how he or she defines what improvements are necessary. It also highly influences his/her perception of safety issues. None of the users considered Leksell GammaKnife lacking in safety features; instead, their assessment was directed towards potential future system improvements. Our findings suggest that the importance of user identity or professional background cannot be neglected during the development of advanced technology. They also suggest that the user feedback should always be related to user background and identity in order to understand how important different issues are for particular users.

1.3.1.3. The Need for Transparency and Rationale in Automated Systems


The second part of the work with the Leksell GammaKnife focused on the support tools built in the system. As medical devices and information systems become increasingly complex, the issue of how to support users has become more important. However, many current help systems are often ignored or found to be too complicated to use by clinicians. In this part we suggest an approach that allows designers to think about user support and automating tasks in a more
constructive way - one that will lead to improvements both in the medical devices and the design/development cycles used in the manufacture of these devices. The issue we address in particular is the notion of transparency and to what extent does it allow the user to understand, make use of and critique the advice given. The concept of transparency is here a representation of a black box problem, where incomprehensible algorithmic representation “stood between” the user and the task preformed. We found that one central problem with existing support systems is that the user does not understand what a number of the differences that exist between the automated parts and the parts that has to be done manually. By taking the aspects of transparency and control into account when designing an automated tool and systems intended to support its use some of the more refractory issues that help systems pose for professional users could be addressed.

1.3.1.4. The Importance of Professional Roles and Identity in Clinical Visualization System Design: The case of GammaKnife Surgery

Dinka, D., Nyce, J.M., Timpka, T., Submitted 2005

This study investigates how the clinical use of visualization technology is informed by the users’ prior experience and training. More specifically, this study investigates how role and professional identity are associated with the use of visualization technologies in GammaKnife radiosurgery. Data were collected through observations and in-depth interviews at three clinics using the Leksell GammaKnife. Data were analyzed using qualitative methods. The users’ professional autonomy, their ability to perform interpretive operations, was circumscribed each time machine visualizations conflicted with their conceptual understanding of clinical reality. The main issue for the users was a lack of transparency, i.e. a black box problem where algorithmic representations “stood between” or “in the way of” the task(s) they wanted to perform. From the viewpoint of a neurosurgeon, transparency means not being forced to take any additional steps -
ones required to operate the GammaKnife and ones that would be contradict his/her previous experience in traditional surgery. From the viewpoint of a physicist, every machine operation that can possibly cause a loss of mathematical precision raises additional, and unnecessary, issues given the clinical problem at hand. In conclusion, designers seem to have equated or confused metaphors, here transparency and toolkit, and have misunderstood what clinical interventions "look like" from the viewpoint of different professional groups. Tool and process transparency are not the same thing and to equate them can lead to mismatches between what operators requires and what designers and developers offer them. Also, what is important within the process, and thereby what is considered as “real” will differ between different users, depending on their background and their view of the clinical process. We have also not recognized that that the metaphors of transparency and toolkit have come more from ourselves than our informants.

1.3.1.5. Adding Value with 3D Visualization and Haptic Forces to Radiosurgery – A small theory-based, quasi-experimental study


This study investigates the use of 3D representation and haptic technology in radiosurgery. The users, experienced users of the Leksell GammaKnife, prefer the 3D representation for constructing a first draft of their plan for neurosurgical intervention. When it comes to the final adjustments, however they still choose the traditional 2D representation and interaction devices. The perceived control over the radiosurgical process is not considered adequate using the 3D interaction methods. In general, practitioners do not consider the haptic forces implemented in this test system useful. Possible explanations for these findings are discussed in the paper.
1.4. Conclusions

In these studies, the importance of roles and identity in advanced technology use was explored. In the area of media producers, the identity of both journalists and non-professional media producers was found to be important when defining user requirements for technology use. Technology that does not correspond to the user identity will have a harder time being accepted. In the case of clinical users, their identity and roles were found to define not only their work, but also how they look at safety and their actual interaction with new technology.
2. General Discussion

As a scientist, I can never be exempt from having a perspective; the sociology is in understanding that everyone else does, too. (Whether I agree or disagree with them is a different question.) [Star, 1989, page 19]

The research presented here shows how the professional user’s identity can depend, relate and be created within the use of technology. If then, the identity is something created in the social context, the technology, it can be argued, is a social actor. Given this, there is a need to further investigate the users and how they identify themselves and their relation to technology.

2.1. To be a Neurosurgeon or a physicist

The profession of neurosurgery has for a long time been closely connected to science, and this close relationship continues up to the present. [Star, 1989] To understand this relationship, one has to first understand how the neurosurgeons themselves define their work. It is equally important to understand their interpretation of the concept of science. As Star points out, the scientific part of neurosurgery is embedded in the practice of the work [Star, 1989]. And, equally important, these situations of work make the science both collective and social. That is: the context where the scientific work is situated is defined, if not determined, not by science "alone" but by the very nature of the organization in which it occurs. Star claims not only that science is social, but also that its very existence is a result from social action, where action can be part of the practice [Star, 1989]. The question is what does this mean for the science, work and
technologies intended to support both. In the papers included in this thesis we have showed how the neurosurgeons believe they have a close relation to science, and that their view of themselves in many aspects builds on their identity as scientists and thereby on their ability to create theories of the surrounding (clinical) world [Dinka et al, 2005:1, 2, 4]. The close connection between science and neurosurgery/neurology as a profession, has been pointed out by Nyce and Graves [1990] and Star [1989]. This has had, different effects on different parts of the work process. For instance, as touched upon in Dinka et al. [2005:1] the issue of safety and risk is seen differently depending on if there is a physicist or a neurosurgery that plan the surgical intervention. A common view of science, especially in neurosurgery, is that science delivers the truth, and the result over time is that uncertainty is reduced [Star, 1989]. Neurosurgeons in other words tend to believe that neurosurgery and their practice of it rests on “true” science. However, the construction of truth (or knowledge) is not, as with many other (medical-) practitioners would have it, the result of "a straight path" of logical reasoning. Instead clinical work and the science that results has much more in common with an open-ended dialectical way of reasoning [Nyce, Graves, 1990], which can be traced back to the history of the field (compare to [Star, 1989]) Within the goal of working scientifically and delivering the truth, uncertainty becomes perceived as threatening some of the basic beliefs of medicine and surgery. Within neurosurgery this uncertainty is even more obvious given the state of what is known today about the brain. Much of the knowledge base used today has its origin from the trial and error of the 1870s where the early neurosurgeons created knowledge (and thereby reduced the uncertainty) in an area where there was little science to guide them and they had to find their way as they went along [Star, 1989]. However, the uncertainty of the nature of the brain and how it is effected by interventions, with e.g. the GammaKnife, is still not fully resolved. If the knowledge of a certain neurological condition is limited, and by definition almost all neurosurgery is limited in this way, how should it be treated and what effects will the treatment have on the
condition and on the rest of the brain. This cannot be fully answered and the uncertainty can become a risk, to the treatment, to the patient and to the practitioner and his or her identity. Attempts to master this uncertainty have been one of the chief spurs to the rapid acceptance and adoption of new technologies like the GammaKnife among neurosurgeons. Sharing of knowledge from others is one way of avoiding uncertainty and risks. The sharing of cases with other surgeons helps the individual surgeon to handle them, and this is especially important when it comes to difficult cases. [Torjuul et al. 2005] Implementing the collaborative and co-operative aspects of neurosurgery into a system would result in more appropriate systems and devices (compare this to Erickson and Kelloggs’ discussion of social translucence [Erickson and Kellogg, 2000]).

Even if its primary goal is to improve treatment, the neurosurgical community will also help its members to maintain (and strengthen) their identities; actually the two mutually reinforce each other. Scientific work influences medical progress in two different arenas. Star describes them as one being the local organizational setting, and the other the national/international discipline [Star, 1989]. In these two arenas participants can assume different roles and different identities. In both contexts, the identity of being a neurosurgeon also involves scientific values. The identity of the medical physicists involved GammaKnife surgery has a strong component of “problem solving”, compared to the neurosurgeon who has a more scientific focus. Their identity is closer to the one of being a technician who solves problems (dose planning) (for a discussion of being a technician see [Barley, 1996]). This does of course not mean that medical physicists are the only ones solving problems; instead this represents the typical stance they take when it comes to treating the brain tumors.
2.1.1. Leksell GammaKnife® and Leksell GammaPlan®

The Leksell GammaKnife (LGK) is a system (including a planning system, i.e., the Leksell GammaPlan (LGP)), for non-invasive surgical interventions mostly directed towards brain tumors (even if applicable on other targets). The concept behind LGK is to concentrate gamma-radiation on a target, and in the case of tumors neutralize the target with the high concentration of energy. From a conceptual and analytical point of view, a description of a GammaKnife intervention would include; diagnose, placing the frame, imaging, planning and the actual intervention. These steps are described at length in the following articles, but to get an overview there will be a short description here as well.

i. Diagnose – The diagnosis is done first, i.a. to establish if the target can be treatable with the LGK.

ii. Placing the frame – In order to fix the position to the head, and to define the stereotactic coordinates a frame is attached by screws to the head.

iii. Imaging – When the frame is attached, images are taken, often using MRI (Magnetic Resonance Imaging) or CAT (Computed Axial Tomography). The frame is visible on the images, which helps to localize the targets and establish the coordinates for the target in relation to the frame.

iv. Planning – Planning is done with the software LGP. Given imaging data, the planner marks where the fields of gamma radiation should be placed (“the shots”) and the software calculates dose volumes and additional data needed for the surgery. The planner decides size and placements of the different shots.
v. Intervention – The actual intervention takes place when the coordinates of the shots are transferred to the LGK and the patient is placed within the LGK. The intervention is automatic in the sense that during the exposure to gamma radiation (the surgery) the patient is moved into the right positions within the precise time spans required by the LGK and a technology called APS (Automatic Position System).

vi. (Maintenance) – The maintenance (quality assurance) of the LGK is not directly connected to the intervention, but still it an important part of the use of LGK. The maintenance includes i.a. precision controls (and their recalibration) regarding position and radiation.

The description of the work performed differed between the different user groups [Dinka et al. 2005:1]. For example, a discussion on how to improve the LGP and LGK showed different priorities between the two users groups interviewed. Even if the tools were considered as very useful and were given high recommendations by users, different issues were considered to be priorities for improvements. As seen in the figure (Figure 2), the different views on how to improve treatments within GammaKnife surgery differs not only in what is considered as a better treatment, but also the means to achieve a better treatment.
Even in situations where there was agreement, differences related to user identity could be found. For example, while many LGP users did not want to make the process more automatic, i.e., having a “wizard” assume a large role in the planning process (an issue discussed at length in [Dinka et al. 2005:2]). While the conceptual description of the problem may look similar, for both neurosurgeons and the physicists, the definition of increased control would differ between the two groups. The increased control from a physicist’s point of view would, again, involve aspects such as accuracy and precision. These issues were not as important to the neurosurgeons. Increased control for them was more directed towards the clinical result and understanding and validating of the effects of the treatment.
2.2. Spreading the message as a journalist or as a political agitator

In the paper dealing with journalists and political agitators [Dinka, Lundberg, 2005] the issue of identity is treated differently than in the work with the GammaKnife. In this study, the identities of the participants were not as heavily marked, as were the neurosurgeons or physicists. However, the identity as a journalist is still very strong, as was the idea of good journalistic.

The identity of journalists is informed, like that of neurosurgeons, by history. The journalistic profession started as commentators on what happens in the world outside. The issues central to what was to become the profession of journalism had to do with power (political or economical) and what effect it had on the people. The throughout the history of journalism had been linked to a concern with professionalism.
and objectivity. [Hadenius, Weibull, 1997] Objectivity since the 19th century have been a very important part in the definition of good journalistic work. It has been particularly important in Sweden, where the critiques of public service have had a long history. For a discussion on objectivity in journalism, there is Westerståhl’s discussion of media and the Vietnam war [Hadenius, Weibull 1997].

When it comes to journalists and technology, much of how journalists use and see upon technology has also been informed by the history of their profession. Technology use has traditionally had two different aspects within the journalistic work. One is to create and produce (message), the other to disseminate information (medium). Late in the twentieth century, the two started to merge, and it has been possible to use the same technology to produce and disseminate information. The Internet and World Wide Web might be the most obvious example. However, the understanding of what journalistic work has not evolved as quickly as the technology. As we have showed in the paper [Dinka, Lundberg 2005], technology that does not match the journalistic/media needs, as mediated through identity, will have problems of being accepted by the journalistic community. Partly this is because journalism link message and medium in a particular way. A message presented in one medium, for example television, can be perceived differently than the same message presented in a different medium, like the radio. A medium that does not “deliver” the same message, the message the journalist intend, will not be considered as useful.

The definition of media use and the understanding of media have been redefined; for example by Bolter and Grusin who introduced the concept of Remediation [Bolter and Grusin, 1999]. Remediation means that we understand and use new media forms in relation to already familiar media. In other words, if we were introduced to a new medium how we would both understand and use the new medium would reflect the experiences we have had with previous media forms. Journalists for example would evaluate new media and media technologies in relation to their experience with other, older technologies and mediums of
information exchange. So, if the media producers or journalists see the existing medias from a specific view, depending on what kind of message they deliver, new media as introduced will be related (and evaluated) depending on which previous media form it is compared to. For example if they believe that television delivers one type of message, and radio another, the new medium like the Internet will be analyzed in respect to how they understand both television and radio.
In the interpretation of purposeful action, it is hard to know where the observation leaves off and where the interpretation begins. In recognition of the fact that human behavior is a figure defined by its ground, social science has largely turned from the observation of behavior to explication of the background that seems to lend behavior its sense.

L. A. Suchman "Plans and situated actions – the problem of human machine communication" 1987 Page 43

This work takes a qualitative approach, regarding both data collection and data analysis. Even if these different studies have different approaches to data collection and analysis, the starting point has been qualitative. The reason for using qualitative methods, and more specifically methods from grounded theory, has much to do with these studies’ endpoints. The studies were planned with an intention to build better tools for either media production or radiosurgery, but there was no "hidden" agenda at work here regarding the kinds of improvements that were required. Qualitative researchers often have to defend themselves against criticism for not being objective [Kvale, 1994]. Kvale turns this question around in his defense of qualitative research. When asked about how to be objective in qualitative interviews he raises the issue of how does one define objectivity [Kvale, 1994 p 151]. Qualitative research should not try to answer the same questions as the quantitative research. Within the qualitative research the knowledge that one is not objective can in fact be an advantage. If you are aware of what you know and what you think, it is easier to be open to (and
research) what you don’t know. Given this, one could even argue that qualitative research has the possibility to approach a research topic with an open and less biased perspective, and this allows both the method and analysis to be “objective” towards the area of study. This is because it is not necessary to specify research questions at the beginning; instead observations and interviews can allow for and integrate what is found at each stage of the research process. In other words, with qualitative research, analysis can be tightly and iteratively connected to the data collected.

The studies presented here have made use of several of qualitative research methods (as described by [Creswell, 2003]) such as open-ended questions, interview data and observation data. Some audio data was collected and transcripted as well.

3.1. Data collection

To collect data in the GammaKnife studies ethnographic oriented observations and in-depth interviews were used. The study with haptics and 3D also included testing with a prototype. During the work with the media roles and identities, data collection took place in workshops that were audiotaped: these were then transcribed. The participatory approach used, in the interviews, observations, prototype testing and workshops, gives the observer a possibility to compare and analyze the knowledge the researcher held with that possessed by users [Garrigou et al, 1995].

The observations used in the GammaKnife research [Dinka et al. 2005:1, 2005:2, 2005:4] were conducted over two days at three clinics. In all three clinics, unstructured questions were asked during day-to-day practice. In addition to these field observations there was also six in-depth contextual interviews [Holtzblatt, Beyer, 1993] conducted, two with physicists and four with neurosurgeons. These interviews were done at the clinics, either in or near the actual planning and treatment locations. The open-ended, unstructured interviews
lasted between 1 hour and 3 hours. The question schedule was prepared with an interview guide [Kvale, 1997] that highlights issues like usability, participant background and work procedures. User experience with GammaKnife among those interviewed ranged from 3 to 36 years. Every interview was audio-recorded and the material transcribed with accuracy to level 2 of Linell's transcription scale [Linell, 1994]. At this level of transcription every word, every repeat of individual words and longer breaks are transcribed. Materials used for analysis included transcribed text and notes taken in the field.

The interviews for the study with the haptic prototype [Dinka et al. 2005:3] were conducted at a conference for GammaKnife users. In this study, a prototype was build and tested with conference participants who volunteered to take part. During the testing, the participants and their use of the prototype were observed, and after the testing the participants were interviewed. The interviews were audio-recorded and later transcribed. The analysis was then made with the transcribed text together with the notes taken in the field.

The workshops used in the research on media roles and identities [Dinka, Lundberg, 2005] were part of a participatory design process intended to elicit user requirements. The workshops were organized as cooperative scenario-building future workshops, using a card-based method [Arvidsson et al. 2002].

3.2. Analysis

The analysis was performed using an iterative approach in which analytic insights and results can be traced back to the collected data. The process was in this way influenced by the ideas of grounded theory and multi-grounded theory.
3.2.1. Grounded Theory

This research has been influenced by Grounded Theory. Grounded Theory is a framework that assumes that a researcher can go into a field situation with little or no epistemological "baggage", this is to avoid potential bias. Grounded Theory also builds up the theory incrementally as research proceeds; analytic statements that are made during the data collection are related back to the data throughout, over the entire course of the research process. This means that Grounded Theory builds up theory instead of testing an existing one. [Strauss, Corbin, 1998]. Below is a short description of the steps in these studies. Grounded Theory vocabulary and terminology has been used below.

- **Open coding** - Open coding data, for instance interviews, is used to discover central concepts or categories. This is the first step in the organization of the data. The concepts created can be phenomenon, qualities or dimensions. In the initial open coding, the researcher decides on which level the open coding will be performed, e.g. if analyzing an interview and the transcription of an interview, a decision may be made to coding at a row level, paragraph level or document level.

- **Axial Coding** - In the second phase, the axial coding, coding continues but this time from the categories are derived from the open coding. Categories, and sub-categories, are discovered, related and generated out from the main categories found in the open coding.

- **Selective Coding** - In the selective coding, theory (analytic statements) start to form. This is the theory generating and refinement part with the aim of validating the central categories.

- **Theoretical sampling** – This process have the aim of verify and investigate possible directions that the emerging theory might contain. A process with the aim of increasing the variation of a
The data collection continues on the basis of the emerging theory.

The main problem with using Grounded Theory, as has been often debated, is how to minimize bias. In this study pre-knowledge about the system used was very low in the sense that the analysis and the data collection started without much prior knowledge of the work processes (the GammaKnife surgery procedure or the journalistic setting as informants themselves performed it). However, since all this research loosely fits into the category of a usability studies, an area with more pre-knowledge from the researchers, there was some prior knowledge of what to look for and what kind of statements that would possibly be key statements before the actual analysis. Rather than trying to ignore the pre-knowledge the structure of the analysis, as time went on, became more of Multi-Grounded Theory than Grounded Theory.

3.2.1.1. Multi-Grounded Theory
While Multi-Grounded Theory is derived from Grounded Theory, it does address the question of prior knowledge. However, there is more to Multi-Grounded Theory than this. Multi-Grounded Theory, as presented by Goldkuhl and Cronholm, also takes on the issues related to data collection and attempts to place Grounded Theory in relation to other theories that deal with qualitative research inquiries. [Goldkuhl and Cronholm 2003]

Instead of, as the more traditional versions of Grounded Theory, propose a direct inductive approach generating categories from empirical data, Multi-Grounded Theory allows the researcher to relate the material and analytic statements, as they evolve over the course of the research process, to existing theories. [Goldkuhl, Cronholm, 2003] In this way, Multi-Grounded Theory grounds the theory not only in the data but also in other existing knowledge bases and sets. What both Grounded Theory and Multi-Grounded Theory warn against is early engagement with theory in the research process. However, Multi-
Grounded Theory not only allows, but also encourages the interplay as research proceeds between the data collection, and theory. In other words, as theory starts to evolve, the knowledge gained can be used in further data collection.

3.2.1.2. The practical use of Grounded Theory and Multi-Grounded Theory

To illustrate how these studies used the methodological framework of analysis derived from Grounded Theory and Multi-Grounded theory, parts of the analytical work with the GammaKnife and GammaPlan will be presented next. As mentioned above, both field observations and interviews were used as methods of data collection.

3.2.1.2.1. Open Coding

The first step was to identify key phrases. Even if the study was directed towards usability and interaction, the initial key phrases were broadly chosen on a document level. Further, issues the participants believed to be important were as were identified as key phrases. The next step was to organize these phrases. This was done by dividing them into categories like subject (for instance software, hardware and frame) and importance (improvement, good improvement, important improvement and necessarily improvement). We also marked the profession of the person making the statement. While we did not at the time do any qualitative analysis with this category (profession), we would use it later on in the analysis. The aspect of subject was easy to identify since the subject was directly visible in the transcribed notes. The aspect of importance was more difficult to infer. It demanded a certain amount of interpretation from the transcription. However, it was still quite clear how much each respondent responded to interview questions when they expressed views like “I really think that they should” or “The system would really benefit from…”

This research also took into consideration the fact that the work informants did (and the research conducted) took place in certain kinds of organizations. It turned out that the importance of categories related
to organizational issues was greater than expected as research continued. Opening coding started with a general "walk through" through the material collected once again. This was done, to find other connections between the categories. In this part of the open coding researchers started to trace out the differences between the users, and the connection to the profession of the users. There were similarities between the users that were neurosurgeons and other similarities between the users that were trained physicists. The interesting thing here is that these similarities, and differences between, that started to emerge was not related to the work (or task) done, but to their professional identities, i.e. this was the first indication of the kinds of conclusions (analytical statements) that would emerge from this research. From this point on, more and more the research began to focus on notions like identity. When the open coding ended, there were three questions left regarding how to categorize the data we had collected:

- Which part of the system did the statement cover?
- How important was this statement?
- What was educational background of the user who made the statement?

The first question is related to hardware and software issues. This is because system consisted of both the GammaPlan and the GammaKnife and the users, at least not on a conceptual level, do not always separate those two. Nevertheless, in the early part of the treatment process, there was most often software issues related to the LGP, and later in the process it was more LGK and hardware issues. However, there could be software issues related to the LGK as well.

When it comes to significance and relevance, every statement was evaluated and compared and finally rated in relation to each other. In references to importance, the different categories used were Improvement, Good Improvement, Important Improvement and
Necessary improvement. How statements were ranked depended on informant comments and the emphasis informants used when talking about them.

The final category in the open coding was the educational background of the users. Fairly soon it was discovered that the users' profession (physicists or neurosurgeon) to a high degree influenced the way that they would look upon the GammaKnife clinical process and on different potential hardware and software improvements.

3.2.1.2.2. Axial coding
When analyzing informant statements according to these categories, it was possible to rank what parts of the system were more or less cumbersome to use. If several informants' comments paralleled each others', this issue was considered more significant. Users with the same educational background tended to rank the same when they discussed priority in reference to hardware/software system improvements.

3.2.1.2.3. Conceptual refinement
Several steps were taken to contextualize these concepts. The first was to go though the material and with each key phrase ask the question of what are they really talking about here. The intent here is trace out the relations, history and functions of context played in informant responses. To do this, transcriptions of the interviews, the observations and the notes from the observation were all used. The result was that the more fundamental issues were identified.

3.2.1.2.4. Categories
In the use of the categories found during the first round of coding, it was found that some of the categories were related and some issues could have been placed in over more than one category. Still, at this point it was decided not to aggregate any of the communities. We were working with a relative small numbers of categories and this had much to do with research's focus on usability and technology use.
In this phase, every issue the informants reported was tagged by subject (software, hardware and frame) and importance (improvement, good improvement, important improvement and necessarily improvement). In other word, every informant statement was, or could have been, from at least three different views.

The main categories that finally emerged were: Attitudes, Control and Support. These were all linked in one way or another to each, as shown below. An example of the generation of sub-categories and their relations to each is shown below. See figure 4 for attitudes and figure 5 regarding control.

![Figure 4](image-url)
Since we started to see the differences between how neurosurgeons and physicists treated concepts and talked about GammaKnife treatment, we turned for comparative purposes to the history of neurosurgeons, the work they did and their professional identity as described in Star [Star, 1989].

3.2.1.2.5. Building structures

The first structure that became visible had to do the attitudes towards the technology and how this differed between the two professions. What the LGK and LGP is (how they were perceived) differed between the two professions. Further, the attitudes the user had towards the system, it become clear, had an direct impact not only on how they used the GammaKnife but also how they defined (and carried out) actual treatments (Figure 6).
After going through the material several times and reviewing what we found in the literature on the history of neurosurgery (Star, 1989), it became clear that attitudes alone were not sufficient to "explain" how informants both perceived and made use of GammaKnife technology. This led us to look more carefully at categories like Risk, Benefit and Trust. These were not easily correlated with (nor could be simply derived from) Attitudes. This led us to look more closely at Identity. Identity, in a working context, is a way of describing through talk and action who we are and how we see ourselves. It reflects our personal history. It is also influenced by the social world and structures within which we work [Wenger 1998]. This modifies the graph presented above (Figure 7).

When breaking the categories down, and the statements relating to them (after all superficially all this work was the "same" or at least had the same endpoints, i.e., to successfully treat patients with brain tumors) it became clear how these differences in identity influenced...
GammaKnife. For example there was significant difference between how the different professions defined errors and successful treatments. This led to the finding that for neurosurgeons identity is in many ways formed by the idea of them as scientists. This led them to define error and successful treatment in different ways than the physicists who saw themselves more as technicians or problem solvers. This can be seen in how they both used the Wizard (or in the reasons both gave for not using the Wizard). The reason for not using the Wizard had to do with a lack of transparency. This was the general opinion of both the neurosurgeons and physicists. This lack of transparency led to, both sets of user reported, a loss of control over the clinical process. This transparency is like the transparency of early computer use. Turkle describes a transparency that allows the user to actually “see”, and alter when necessary, the mechanics behind the process [Turkle, 1999]. Transparency was not an issue users believed when planning was done manually and users were able to confirm for themselves that s/he made a good plan (see Figure 2).

Further analysis showed that the definition of a good plan differed between neurosurgeons and physicists. The need for (and ranking) of improvements also differed by professional group. Here the identity of neurosurgeons as scientists and physicists as problem solvers became visible (see Figure 3).

3.2.1.3. About the use of Multi-Grounded Theory
Because of constraints imposed on the research design, it was not possible to follow all the injunctions laid down in Multi-Grounded Theory. The interplay between research results and further investigation was not possible, due to time limitations and the physical locations of the different sites. By taking a grounded approach from the beginning made it possible to make the observation and interviews without extended knowledge about the neurosurgical procedure. This made it possible to observe connections and relations that otherwise would have been difficult to trace out. There were some pre-knowledge derived largely from the usability literature that to a high degree
informed both the observations and the result. The benefit is then, as we see it, to be outside the specific knowledge held by informants, but to apply to what they know, practice and believe a framework that can produce analytic statements. Grounded Theory and Multi-Grounded Theory has its own limitations. First, it offers little or no guidance regarding what is called pre-knowledge. In this research, we benefited from having the pre-knowledge of usability and interaction design, since it helped us to more easily identify the problems using the LGK-system that otherwise might have been overlooked. We also think that it was beneficial for researchers here to have had some minimal knowledge about the actual system. This leads to the second point, the generation of pre-knowledge. Over the project’s lifetime, the knowledge we gained about the LGK-system increased and this influenced the collection of data, even before there was any analysis done. This of course raises the specter of basis. A potential solution might be to have different sets of observers carry out interviews and field observations. This is, of course, not possible here but perhaps a more structured way of to handle the knowledge gained during the process (before the analysis) would have been useful. One has to beware of, and better able to take into account issues related to pre-knowledge, both that one gained during the research and that which one “brings to the table”. If the observer, and maybe more importantly the one doing the analysis, is aware of her/his pre-knowledge and acknowledges the role it plays in both data collection and analysis, its presence will strengthen rather than weaken the research process.

The movement from a Grounded Theory to approach a Multi-Grounded Theory approach made it possible to add a historical perspective in the research. It also made it possible to bring to the research, as data collection and analysis proceeded, a theoretical background that lead us to better the interplay between the organization and the professional user [i.e. Wenger, 1998].
3.2.2. Other publications not included

3.2.2.1. “The Snatcher Catcher” – An Interactive Refrigerator
Lundberg, J., Ibrahim, A., Jönsson, D., Lindquist, S., Qvarfordt, P. NordiCHI’02, October 19-23, 2002, Århus, Denmark,

3.2.2.2. TNT – A Numeric Keypad Based Text Input Method
Ingmarsson, M., Dinka, D., Zhai, S.,(2004) CHI ’04, April 24-29, Vienna, Austria.
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5. Identity and Role - a qualitative case study of cooperative scenario building

David Dinka, Jonas Lunberg. Revised version submitted to the International Journal of Human-Computer Studies

In this study we argue that users participating in the design process will form the participation as a function of their professional role, but also as a function of their identity more or less independent from their role. In order to get the full potential of cooperative design the user identity in general and in this case their attitudes towards technology in particular should be incorporated into the design process. This case study consists of participatory design sessions with two different organizations, in the context of a media production tool development project. Facilitator skills, and workshop interventions to balance attitudes and to take them into account in design are discussed. Furthermore, we argue that attitudes will affect a subsequent implementation of a technical system, and that knowledge about stakeholder identity can be useful for further design activities and for planning system implementation.

5.1. Introduction

Scenarios are a well-understood and useful means in design of interactive systems [Carroll, 2002]. One way of achieving scenarios is through cooperative design, through card based game-like methods
What is not well understood in previous research is how participant’s non-procedural knowledge affect and can be useful when creating scenarios together with user representatives. Previous research for instance has described how issues of conflict and consensus emerge between groups of different stakeholders, when conducting card based design within future workshops [Arvidsson, et al 2002]. That research did, however, not show how such clashes of interest emerge within workshops. Although not addressing card based design specifically, Novick and Wynn [Novick and Wynn, 1993] propose that natural discourse in design teams should be analyzed to identify differences between both successful and unsuccessful design sessions. They argue that design is primarily conducted through talk, but that this talk is affected by social differences between participants and communicative conventions within a design session. A study of the verbal communication of a mixed team revealed that people participated differently through their conversational conventions. The main conclusion was that attention to these differences is necessary to evaluate whether all participants have made their contribution to inform the design [Wynn and Novick, 1995]. This indicates, but does not fully reveal, the importance of interaction of individual participants in card-based design work. Each participant enters the design situation with his or her own personal history. Every statement and every action taken by each individual during the process is not only a reflection of the professional roles these individuals represent, as users of technology. Each interaction also reflects the individual’s identity and attitude towards technologies.

In this paper, we analyze participants’ design actions and statements in three design sessions, in terms of their role (what they do), identity (their values and opinions), and attitudes (their pre-conceptions) towards technology. To conceptualize these ideas and relate them to each other we use the concepts of benefit (positive relation), risk (negative relation), and trust (benefits with a time perspective). The analysis show
how participants draw upon these three aspects in their design work, making important design decisions. These initial impacts of the participant’s identity will form the design, it will also define the risks and benefits (and thereby potential trust) towards the technology related to their need and requirements. We propose how card-based design could be carried out to make the non-procedural aspects more explicit, making the design rationale available in subsequent design work.

5.2. Background

Different users have different aims and stakes, connected to their professional role and how they identify themselves within that role. This professional role is built on the tasks that a specific position within an organization includes. The role is then orientated towards the organization compared to the identity that is of a more individual character. The definition here of the role is connected to the organization and to the task given by the organization, e.g. the role of being a CEO involves specific acts and ways of solving tasks, the role of a being a secretary involves other ways, and so on.

There are differences between this official role that individuals are expected to play, and how they look upon themselves: their identity. In a professional situation, the identity stems from the personal history and develops during the individual learning process that takes place in an organization. This makes identity partly defined by the operational community [Wenger, 1998]. It does not, however, define the identity as the role. Wenger uses several different levels when treating and analyzing the identity in a community of practice. Here we emphasize a different distinction i.e. between the identity and the role in the organization. This is done to make explicit the difference between the personal agenda that users have (the identity) and the agenda of the organization (connected to the role). The identity, the way a member of a community sees himself or herself, does not necessarily correspond to the role that he or she has in the community. For instance, in clinical
situations, the identity of a neurosurgeon or a medical physicist will differ even if they have the same role in the sense that they are performing the same task. They will identify themselves as either a neurosurgeon or a physicist, but their task will be connected to their roles, and these roles could be shared by both groups [Dinka et al 2005]. Identity involves many attributes that are not specific to the organization. It can be individual history from previous organizations, education, and it can also be gender and nationality. It can moreover involve specific, attributes like education, and work history. Here the distinction between role, as an organizational position, and the identity, as the users self-image, is the most important.

The experience that these attributes build up is also a part of the identity specific attitudes that is constantly changing and evolving. As a part of the identity, the attitudes are an important aspect in how to interact with the surroundings. Attitudes can be treated as preconceptions, and will then, as such, form the interaction of every new situation and every new environment that the identity is confronted with. Giving the fuzzy concept of attitudes a more concrete meaning, Sjöberg [Sjöberg, 2002] discuss aspects such as risk and benefit, where risk is seen as the more important. Building an attitude, i.e. a pre-notion of something, there will be an individual judgment of the risks and benefits that the target for the attitude will possess. If the risks are considered as stronger than the benefits, the attitude will be negative. Depending on the subject there can be different targets for the risks and the benefit of a subject, i.e. what is threatening by the risks and to what is it beneficial. It is however not all about risks and benefits, there is also a connection to possible trust that the user have towards, in this case, technology. Gustavsson and Dellve [Gustavsson and Dellve, 2002] discuss the attitudes among young adults as being divided into the dimensions of opportunities and risks. Connected to opportunity were aspects such as freedom and efficiency and connected to risks were restrictions on living space and intangibility important aspects. These risks and opportunities were related to the
use of the technology for the special target group (young adults). In the present study the tasks for the users differ and thereby the risks and opportunities, whereas opportunities are closely related to the benefit approach addressed by Sjöberg.

Some management theories also discuss risks and how acceptance of a risk equals trust, depending on the depth and dependency connected to the relation [Sheppard and Sherman, 1998]. Even though the trust that Sheppard and Sherman talks about is related to business and management, there are similarities to the attitudes that users of technology have towards the technology. The use of a technology can be seen as a relationship built on trust, risks and benefits. This becomes even more evident when analyzing what causes trustworthiness. Sheppard and Sherman describe consistency, transparency and predictability as key attributes of trustworthiness [Sheppard and Sherman, 1998]. These aspects are also well known in the HCI community as key aspects of successful design in many settings.

Thus, when introduced to e.g. new technology, the user of the technology will consider the risks and benefits of this technology, firstly related to their identity, since the identity is personal and therefore have a high priority. If the identity is not threatened, the user of the technology will develop trust towards it. Secondly, the technology will be evaluated in relation to the role in the organization that individual user have. This evaluation is then directed towards the actions and task that the user is presented to and uses the technology for.

Here, we present a case study of collaborative design sessions. It involves future users in the design process, as co-designers. That is common in for instance the Scandinavian participatory design approach [e.g. Greenbaum and Kyng 1991]. It is also common in north-american joint applications development. In collaborative design, users give design proposals, and participate in decision making about the way design should go forward. They do that together with other
stakeholders. The users thus have much more influence on the design process, than if they are merely test subjects of prototypes in different stages of the design process, or if they are just seen as sources of information, in a requirements gathering process. It is clear from previous research that different stakeholders make different priorities and judgements in design processes. Bødker, Grønback & Kyng [Bødker et al. 1993], for instance, focuses on conflicts between management and labour, which is a common focus in Scandinavian participatory design. During collaborative design, users participating in the design process thus make decisions that are sometimes in conflict with decisions made by other stakeholder groups, in other design sessions [e.g. Arvidsson et al]. There can also be conflicts between participants within design sessions. Moreover, in light of the theories on role, identity, and trust [Dinka et al 2005, Wegner 1998, Sjöberg 2002], it is likely that there are also sometimes conflicts between participants role and identity. However, there is a lack of knowledge about how these conflicts between role and identity are expressed during collaborative design sessions, and to what extent they affect design decisions.

5.3. Data collection and Settings

In order to investigate the importance of identity related attitudes in design work; we turned to the audio recordings of three workshops. The study included two workshops with journalists, and one workshop with a group connected to the new social movement (from here known as the political group), as part of the context of use analysis in a larger research and development project. In the design work these two first groups were selected for analysis because they had similar stakes (their future newspaper work with new journalistic tools). The third group was selected, because it had different stakes (how they would be affected by new newspaper services). The groups were not selected because of their specific agenda or political viewpoints.
The first two workshops had the purpose of envisioning the impact of new journalistic tools and consumer devices on journalistic work. The first workshop was conducted with staff members from the printed edition and the radio. A programmer and a news director were also participating. There was in total six participants and two facilitators. The second workshop was conducted with staff members from the online edition, including a web advertisement seller, and the news director from the first workshop, in total six participants and two facilitators.

The third workshop, with the political group, had three participants from that organization, and three facilitators. These participants had no official role within the political organization, partly because the structure of the political organization. However, each participant could be seen as having the role of opinion maker within the organization, i.e. each of these were active in posting posters, sending e-mail and participating in demonstrations arranged by the political organization. The purpose was to envision how future online newspaper services could affect the political group. The main objective for that organization was to make the general public aware of their message and to create opinions on, for the organization, important issues. Thus, one participant, the news director, was active in all three workshops, but had the role of facilitator in the workshop with the political organization. The motivation of having these three specific groups, from the point of view of systems development, was to frame the use (spreading messages) and still get different perspectives on the task.

The workshops were set up as cooperative scenario-building future workshops where a card-based method was used [Arvidsson et al., 2002]. The workshops duration was half a day each. The main idea of a future workshop is to divide activities into phases, where critique and problem formulation is the critique phase, futures are envisioned without criticism in the fantasy phase, and that future is evaluated and an action plan is created in the implementation phase [Jungk and Mülbert 1996]. The workshops followed the general phases of a future workshop (Figure 8), with an introduction, a critique phase to formulate
problems, and a fantasy phase to envision a desirable future. However, the implementation phase was omitted, since the workshops were part of a development project. As recommended in the literature a vision exercise was used as the transition between critique and fantasy. Also, to facilitate the understanding of new technology possibilities, a technology presentation was added to the workshop, in the trigger phase.

**Introduction / warm up phase:** After a brief introduction to the development project, including a short introduction to the future technologies, there was a short idea discussion, regarding the usefulness of the new technologies, as a warm-up exercise.

**Critique phase:** The critique phase was a brainstorming session about problems the participants could see with the new technologies. The problems were summarized as statements by the facilitator on large sheets of paper. As a trigger in the critique phase, in the first two workshops a video illustrating new technologies in the newsroom [IFRA 2000] was used, whereas in the third workshop, a verbal description was used.

**Vision:** As a transition between the critique and fantasy phases, each problem was discussed, to envision its opposite. Problems may have different opposites, and were in some cases discussed, when some participant opposed the first suggestion.

**Fantasy:** In the fantasy phase of the workshop, card based scenario building was used.

The card-based method was based on well-documented methods such as CARD [Muller, 2001], CUTA [Lafrenière, 1996] and PICTIVE [Tudor et al., 1993], but had slightly different card layout and rules.
Card-based design was initiated by a brief explanation of the rules and materials by the facilitators, followed by selecting a scenario. In the workshops with the journalists a news event was selected, and in the political group meeting, news related scenario was selected. Then, a scenario was created to envision how that event could be treated, with the future vision and technologies as a frame of reference. The scenario building activity was initiated by the participants filling in a card labeled “what?” with a brief label of the event to cover. Then a scenario was constructed elaborating the event, by the participants, filling in cards, each labeled “what?” “when?”, “how?”, “where?”, “tool?”, or “who?”. The scenario cards were grouped in activities that would be part of the event. These cards elaborated first on what the activity would be about, second on when the activity would take place, third, on how (in what manner) the activity would be carried out (i.e. manually or automatically),

Figure 8: Workshop phases

Figure 9: An example of a scenario card
fourth, on where (at what location) the activity would take place, fifth on what tools would be used and sixth, on who would be involved in the activity.

Participants were seated around the card-based scenario that they created. The cards were placed in the scenario either by the participants or by the facilitator. The facilitator asked the participants to fill in cards and place those on the table if the process of filling cards faltered. Also, the facilitator kept track of the completeness of the scenario, trying to probe the participants to fill in apparently missing or incomplete parts.

![Figure 10: Scenario were created by placing cards](image)

5.3.1. Data Analysis

All workshops were transcribed. The transcription included hesitations, pauses, and aborted and interrupted utterances. This level of transcription corresponds to level 2 in Linell’s method of transcription [Linell, 1994].

The two authors then individually analyzed the workshops, highlighting expressions indicating relations between attitudes, identity, and roles. To exemplify this, consider that a suggestion would be made by a participant, to use a tool, for a specific task. Then, if another participant states that it would be a bad solution because the role does not have the competence needed for it, then this evaluation is done based on
the role. But if the participant instead says that the solution is bad, because it violates some journalistic ideal, such as checked facts, then the evaluation is done based on identity. Or, in the case of the political group, if the solution violates some political ideal, such as being independent from strong capital owners, then that is also an evaluation based on identity. In the first analysis step, the authors marked such sections without going deeper in the analysis. After having marked sections were attitudes were expressed, the authors compared and integrated their results with each other.

In the second analysis step, the authors conducted a more detailed analysis, highlighting whether the attitude expressed was of benefit, trust or risk. The authors also highlighted whether the attitude was related to role or identity. Then, the authors again compared and integrated their results with each other.

5.4. Results

The goal of the workshops were to achieve scenarios of situations where the technologies would be used for different ends, together with overarching risks, and visions (benefits). The result show clearly that this was no simple case of eliciting information possessed by the participants, regarding the situations of future use, or the visions and risks. From the identity of the participants and the roles they have in the existing organization, the participants created assumptions about future technology and used this as a point of departure in this design process. This does not mean that the values that have its ground in the identity always corresponds to the more organizational and task oriented goals of the role. They could not rely exclusively on their experience, since the new technologies would open possibilities of genre change, thus potentially changing the form, the contents, and the situations where the genre could be produced and used. It was furthermore not a situation of creating completely new scenarios, since the scenarios would remediate current practice, but include added values through
exploiting technology potential. The benefits and risks of the new tasks and their outcomes were moreover not known beforehand.

In the workshops, thus the outcome would range between two extreme points. The scenarios could be mainly conservative, drawing heavily on the participant existing competences and roles, but merely describing current practice. Alternatively, the scenarios could be very futuristic and explorative, relying less on current practice, but then also less on their knowledge of the tasks. As it turned out, not only was the expected mix of future oriented and conservative aspects explored. Also, during this process of envisioning and discovering possibilities, risks and benefits based on identity and role were expressed regarding design proposals. Depending on the attitude expressed by participants, the proposals were either rejected or placed in the scenario structure. These risks and benefits were discussed both from the organizational (general) point but also from the (individual) role of a professional actor. Consequently, also for the proposals regarding new possibilities, the participants were drawing on their own particular viewpoints.

The underlying point of identity was not directly addressed but became visible throughout the analysis of the workshops. It was more visible in the political organization than in the workshops with the journalists even through it was clearly present in all three. It was also an issue of integrating new tasks in previous activities and roles, although what these new tasks would be was not known beforehand. The role of being an editor could in these future scenarios include tasks that the current role of being an editor would not include. A difference in the organizational structure connected to the role was discussed and explored.

Two examples of scenarios used were a bus accident scenario by the journalists, and an upcoming demonstration by the political group. The Bus Accident scenario was built upon a real event, which had happened prior to the workshop. This scenario covered a bus accident and how to cover this news event, both from the perspective of
professional roles during the coverage, but also from a media perspective in describing what media will be covering the news. The resulting scenario built upon current journalistic practice of print and still images, but added new features, such as 3D animation and video. This scenario illustrates that journalistic knowledge was not simply elicited in the design session; on the contrary new journalistic tasks were added to the scenario, of which the participants had no first hand experience.

The political group also based scenario building on a recent event, similarly adding tasks of reporting the event. Not all of them had news reporting experience, but instead they had experiences regarding the problems of the organization to reach out and engaging people. This scenario focused on how to spread the message of an upcoming demonstration in the centre of a middle-sized town in Sweden.

5.4.1. Identity framing the design

Risks and benefits of old and new technologies were discussed in the journalistic workshops, related both to their identity and to their role. Considering old technologies, for instance, one journalist expressed that television was a medium for emotions, whereas print was more for facts, and print gave more control over reading. Also, they viewed television as a problematic medium seen from the point of view of their journalistic role, since it demands a constant flow of content. Considering a more specific example, they thought that a low quality video of a hockey game, produced by an amateur, would turn people away. This shows that they had a critical view on existing technology, even though they did not reject it in general. It also illustrates how arguments for or against new ideas often were based on their view on good journalistic work, which included assumptions on audience experience.

They also found benefits of new technologies, based on their role, such as being able to quickly deliver breaking news of high value, and of being able to reach their audience, either selectively, or at different
locations. Considering another example, the web edition was seen as combining some good qualities, being able to communicate both emotions and facts, while giving the journalists more control over reading. However, the journalists also viewed the current web as a medium where facts were not as reliable as in print. When introduced to new technologies they thus kept their critical thinking and evaluated them from the perspective of risks. E.g. the expected demand of a constant flow of new contents would become a problem also for an online video edition. Here are some examples of how people reasoned about the themes brought up:

"The great advantage of the web, or the advantage of WebTV is the possibility to combine text and motion picture in a more natural way than the television can do today"

"It becomes a damned recycling of news, and that results in boring media"

"It could be a nation wide news item; they get something they would otherwise not have, just because they (do) not live here"

Note here how the comments include both identity-oriented aspects regarding news quality but also more role-oriented aspects of technical combinations in news reading. In this way, the design activity in general was framed by evaluations of what the new technologies could contribute with (benefit), and what problems might occur (risks). These benefits and risks were thus evaluated in relation to the identity and role, i.e. a positive attitude was expressed towards proposals seen as beneficial for them as journalists – including both benefit for their role as news reporters, and their identity as delivering good journalistic work.

In the journalist workshops the benefits and risks of live reporting were seen as a main issue. The journalists expected two quality problems regarding live reporting. The first was to have low quality material, e.g. videos, or poor images, even though depicting the intended objects. The second was poor content, for instance, interviews with accident
victims in ethically questionable ways, lacking the time for afterthought and time for that second viewpoint on the material. The reader preferably should be protected from disturbing images, and in particular they should not have to receive bad news about loved ones through the news channel. They viewed professional knowledge as the only remedy to these issues, while agreeing that in some cases, lower quality of form would be acceptable. Hence, these problems were seen in the light of their identity as reporters of good journalistic work, although live reporting could be a benefit for their role, giving new possibilities for the actual reporting of news.

A difference between the web journalist workshop and the print journalist workshop was that the web journalists were more often satisfied with their current technologies, rather than finding new technologies to be an improvement. In some cases, as a consequence their good experience with current (or old) technologies motivated sticking with these.

"I think that I am that conservative that I will be there with a paper and pen, because you are not writing the actual text, it is just raw material"

During design, the journalists discussed the relation between new and old roles; which ones would be needed, what tasks they should carry out, and whether some people should have more than one role, i.e. if they could have more than one task assigned to them. The professional video news reporter was seen as missing from the current organization, and this was also the case for illustrations through animation. Moreover, it was discussed whether some tasks could be supported by automation, such as reformatting text for different channels. However, automating is also a risk colliding with the journalistic identity:

"The main idea is that a news item should pass several eyes, in my opinion that is a way to get quality and therefore it should be someone that has an overall perspective on what is published in different ways. In a way the news director has that, but it is probably not him that is in the
practical position, so you would need another person who is editor and publicist…”

In the political organization workshop, the focus was more on the risks than on the benefits with technology in general and then often connected to the identity. They often came back to risks, such as that human contact will be lost with more communication through media technology. The ideal way of communication for this group was face-to-face communication. On several occasions’ members of the political group expressed that they did not have anything against technology in general, only how it is used today. This became the fundament of why they have doubts about future technology.

"It is not about being hostile to technology or positive to technology. It is all about what the technology is going to be used for, right? //. I’m positive to technology, but I am afraid of were it will end up and that it is going to be used in the wrong way, because that is what has happen so far."

Also here we can see that the criteria’s of judging technology lies within the scope of the organization member’s identity and not to the function of the technology. The function of a specific technology has to stand back for the more emotionally oriented opinions of what that technology is associated with. Describing the ideal form of communication as face-to-face between people, a problem for the political group will be to reach and engage a larger audience. In this description they have also a built in attitude of what is the “right way” of communication. They considered the traditional media, such as TV, radio and the newspaper to be the main media for communication to the outside public. The current use of the Internet as a medium within the political group was mainly email conferences within the organization. This was seen as problematic, even if the preferred way was face-to-face it becomes hard to reach out and engage people outside the group through that means. In their view, their problem would not be solved, but on the contrary become more difficult to
solve, with more media technology. They could see a risk of increasing information overflow, which overshadowed benefits of reaching more people. The role of being a messenger collides with the identity, judging bad and good tools for communication. Nevertheless, they viewed media organizations as being responsible for reporting on their public appearances, such as demonstrations, and for covering the political contents of political events. They were disappointed with the lack of media coverage, relevant to their political agenda. The political group often focused on already available traditional technology, such as printed papers or radio, to solve their problems. Other technologies, even old, were seen as problematic. The reason for this was seen as a combination of control by owners, and need for revenues, leading to an orientation towards entertainment in media, and control of what viewpoints are possible to present in media. However, whereas the web, for instance, was seen as a good channel, messages were seen as not reaching a wide audience.

"We don’t need another medium; we really don’t"

"If we get another media that will just reach a small audience, then we are not helped at all"

"And then the question is: should I have even more information resources that I don’t have the time to use?"

Here the attitude of the technology is already set, and the potential benefits will be hard to acknowledge. However, it was not only these identity-oriented tasks that were seen as problematic. From their experience of technology, more role-oriented issues like know-how within the organization would also be a major problem, considering new technologies.

"Looking from a practical point of view, we have to have both competence and capacity, right? To do this kind of thing on our website, then we have to have help, because I do not see that anyone in our organization have this knowledge right now..."
5.4.2. Discovery and negotiation through scenario building

During scenario building, the future that the political group discussed was a negative vision based on how technology had been used so far. However, when it came to the small scene, to local engagement, the participants did discover benefits of using new technology. This was manifested in suggestions of advertising an upcoming political demonstration through mobile phones, and to take part of the speeches, from afar.

"I would love to have the possibility to listen to (the speech) even though I was not able to be part of the demonstration"

"The whole square filled with people, can you imagine?"

These positive aspects are more oriented towards the functionality, and thru the functionality they had a possibility to “override” the negative attitude connected to their identity.

To be able to quickly and inexpensively cover events was seen by the journalists as motivating lower quality video news. Regarding events with a longer time span coverage, they expressed concerns about the quality of their equipment, and also about competition from television media companies. Deadlines or being at several locations could be an excuse for having a lower quality of the presentation of video news. Consequently, the journalists weighted quality criteria, which they found to be important, when making design decisions, especially when it comes to using low quality for a longer period of time. The role-oriented functionality is then related to the identity-oriented quality, and analyzed back and forwards between the two.
“Webcams and alike, it is cheap and it is fast, right? But when...these things where the speed turns into a long relationship, well then you are in a discussion of quality”

“...well, then you have to lower the quality criteria, being at several places at the same time”

These points in turn raised the issue of getting an overview, from the production point of view but also from the reader point of view, of a developing news event. Thus, the backtalk of the design activity was directing the group towards new issues, rather than having the issues simply being elicited from their pre-workshop knowledge.

The new scenario aspects, not elicited from recollection of personal experiences, were not simply added, as indicated in the previous section. Instead these aspects were designed into the scenario, by being related to pre-workshop knowledge and values. Some of these technologies were seen as a risk, threatening the independence of the newspaper and therefore the credibility of the newspaper. For instance, automatic selection of advertisements, based on news item index terms was compared to telling the advertisement sellers about the news in advance, which was considered as unacceptable.

“Then we are getting a situation where the advertisement department knows what the paper looks like tomorrow, or what the web based paper looks like”

Here the different roles within the news-organization (the journalist and the advertisement seller) collide and the journalistic identity (the value of “good journalistic work) will be the aspect that decides weather the technology could be useful or not. And like in the political organization, the identity of the journalists becomes related to the one of the organization. The two interest of selling advertisements versus delivering good journalistic work is however both crucial for the survival of the organization.
"From a journalistic perspective, there will be a danger if we are being bought to do an article because someone expect to sell...”

The idea of technology that would make parts of the publishing work automated also collides from a different perspective with the journalistic identity.

"At the same time, the actual point with journalistic work is that the reporter finds out what is important.”

What this also implies is that the reporter, according to the identity of being a “good journalist”, also chooses and values each subject and parts of subjects that are to be presented to the viewer. In the role of being a writing journalist, they use their identity-based values on a day-to-day basis. The solutions discussed had to take this “good journalistic”-identity into account, however, the discussion did not end because there was some risks associated threatening the journalistic identity. In the end a solution where it became clear what was the journalistic material and what was the advertisement was considered as an acceptable solution. A solution that took both the identity of good journalistic work, and the role of selling adverts into a paper into account for the benefits of the organization.

In the workshop with the political group, a technology remedy to their problem with a lack of technical competence was proposed. This was to utilize the media company publishing tools and system, to create contents without extensive technical skills. The suggestion was not well received.

"I mean, make you dependent, too dependent, of some sort of “mecenat” or someone who is supporting... that could be dangerous...”

This reflects their distrust towards media organizations, which demanded that they should be independent from them and their tools. Their remediation of the new technology made their pre-notions of the
new media and technology very negative. Also, on the one hand, they did not want to be responsible for being a part of the information overflow, whereas they on the other hand wanted to reach everybody with their information. Balancing risk and benefit, reaching out to people in other organizations positive to their political agenda through a community portal, was seen as an acceptable solution as long as they had control of the tools providing this service. If they were able to find a way that they could sustain control over their own material, then they could consider using tools or technology provided by a news organization or a company.

5.5. Discussion

We have showed the importance of incorporating and focusing on the user identity and personal history during the design process. By exemplifying with scenario building and card based design methods the use of the concepts risk, benefit and trust has turned out to be essential in this kind of design work. The information gained during the scenario building turned out to be very useful for the design project in which the workshops were a part. Important information also emerged in parts of the sessions when the participants adopted a negative attitude. A system disregarding these values might contain functionality which if used might at worst actually harm the organization, which it should support, or might be a waste of development effort, if left unused. With too much of such functionality, the users might reject the entire system. But equally important, at some instances, new ideas were tested, and found acceptable, thus gaining benefits of the technologies without violating important values.

5.5.1. Identity and role

The reactions towards the new media technologies can be explained in terms of participants’ identity and secondly in terms of their professional roles within the organizations. For instance, when the
journalists describe the drawbacks of online video, the main drawback pointed out by the journalists was the risk of low quality. However, if the news value were high enough, the low quality would be accepted. This might lead to an acceptance of the technology in the way that being prepared to accept a certain risk can lead to trust, like in the theory of management [Sheppard and Sherman, 1998]. This suggests that the quality aspect on its own is not sufficient for acceptance. The identity of delivering “good journalistic work” has a higher priority than fast delivery of news or the delivering of news that always have a very high technical quality (compare to Wenger’s definition of identity as partly defined by the operational community, [Wenger, 1998]). Quality does involve both the quality of the actual news, but also the quality of the video. So, why is this not a role aspect? Their identity is closely connected to the participant’s role, more connected than in the political group, they see themselves as journalists. Being a journalist stands for qualitative and investigating news delivery. Their role within the news organization is different; they could have the role of editor, reporter or manager. It is not these roles that make them doubtful about the technology; it is their identity as a journalist (delivering good journalistic work). If their identity as journalists is not threatened, and if the technology could be seen as a benefit rather than a risk, the technology and the technology uses becomes interesting. Even if the risk element is stronger, this could create a positive attitude since the benefit is beneficial enough. [Sjöberg, 2002] If it was visible that new technology would be beneficial in the journalistic work, i.e. the technology had gained enough trust; the need of journalists with different roles could be discussed. Again the example of speed vs. quality is a good illustration. In this discussion the speed aspect would fit in the role of the journalist. But there is a problem with the speed aspect, and that is the quality of the news, this is both from a technical but also, more importantly from an ethical perspective. The identity of the journalist as broadcasting news with a certain (ethical) quality then conflicts with the role as the journalist with the technological possibility to spread news very fast. Since the threat
against the identity is greater than the benefit for the role, the judgment for e.g. “web cams” is negative.

The political organization did not have roles that were equally clear compared to the journalists, the roles of for example public relations or secretary was not connected to one person and not static. The participants in the workshops identified their organization more as an extension of their own identity. Their opinions would form the opinions of the organization and the organizational needs. This was shown in the focus on risks of new technology, and not on the beneficial aspects of new technology. This has much to do with the nature of a political organization; the organization is a collection of people with similar opinions. Since media, and how it works today, in many ways represented things that did not fit the participant’s identity or opinions (and thereby the agenda of the organization), new technology was seen from a skeptical point of view. Having a political identity as the foremost concern, these participants could more easily identify themselves with a situation where they talk face–to–face with their target group. This also shows why TV, radio and traditional newspapers were seen as their media of choice. These media (TV, radio and newspaper) have a stronger profile (with these users) as deliverer of political opinions, even if the message that these media is spreading by themselves is not unproblematic. The problem with both new and old media is the delivery through channels, rather than being the face-to-face communication that is part of the political identification. The community identifies themselves partly in contrast to others; their non-participation becomes a source of identification (see [Wenger, 1998]).

It is not until these aspects are discussed, and considered as problems that can be handled, that the participants from the political group start to think about if their organization possess the knowledge that might be needed within the organization, i.e. the roles in the organization. The practical aspect, that involves the roles, is also a problem but is not the main objection towards the technology. Here one can take the example of being a political group spreading a message (a function connected
to the role) vs. the channels which to use, depending on what they stand for (opinions connected to the identity). If the message would be isolated from the identity, the group could in theory use every media to spread it. But, since the message is closely connected to the identity of the members of the group, they can not use channels that threatens their identity, i.e. channels that from the participants point of view stands for political messages that they could not identify themselves with. This is even if they think that their role would benefit from this; their message would reach more people. Their identity as political movement was more important than the role of deliverer of messages. For instance, even if the use was seen as beneficial, it was still a threat to their identity as political actors to be dependent on a specific channel of media.

5.5.2. Suggested development of the design method

The analysis of the workshops showed that identity (and what builds the identity like history and attitudes) has a significant impact on the procedure, both on the design process and on its results. The question then will then be how to use this knowledge to improve the design process. First we focus on a phase model of a future workshop [Jungk and Müllert, 1996] that was not sufficiently powerful to direct risks to the critique and implementation phases, and benefits to the fantasy phase, since risks were frequently voiced in the fantasy phases of all workshops. Clearly, it is an advantage to introduce risks in the scenario building activity, when the participants subsequently find solutions that solve the conflict between risk and benefit. Similarly, in this kind of workshop, it is a disadvantage to have a critical group with too few attempts to solve risk-benefit conflicts, or where scenario building is based on risk, rather than benefit.

As shown in the present study, when a scenario is created, the participants bring pre-notions that affect the outcome. The scenario
created is then greatly affected by the identification and the attitudes that the participants bring to the workshop. The identification (and the topics discussed in the workshop that will provoke the identity) is affected by the attitudes of the participants, but also by the technology demonstration in the beginning of the workshop. In the technology demonstration the participants are positioned in their thinking and the level of understanding of pros and cons is also framed. By having a small arsenal of tech-intros, the facilitator could chose the ones that suits the group represented and the attitudes represented in that group. The problem that a facilitator faces is that it might be hard to know the attitudes of the participants in advance, although these will be revealed during the workshop. It would thus be hard to prepare one technology demonstration that is equally good for groups regardless of their attitudes.

If the participants put themselves in positions that are either too negative or too positive, and in that way disturb the balance that is needed to make a creative workshop, the facilitator could intervene. To create a balance, the facilitator could give the role of critical analysis to one of the participants and the role of over-positive to another. To maintain the balance, the facilitator could change the roles throughout the workshop, if necessary, for instance by using the six thinking hats technique [de Bono, 1993]. It is also possible that the role of critical or positive could be taken from a person outside the group. This was partly tested in the workshops here, since the participant present in all workshops always took this role. It did work out quite well in those workshops.

A final suggestion to the procedure of the workshop would be to add a new type of cards to the workshop. By explicitly introducing a card that had the criteria of Benefit and Risk written to it, more of the ideas could be captured and parts of the evaluation discussion would then also become documented. It would also make it possible to have a more open discussion about risks and the benefits of solutions that otherwise might be rejected direct by critical participants in the group.
Implementing the proposed interventions could improve the quality of the results from cooperative scenario building future workshops, and thereby make design building on these workshops more usable. However, the suggestions presented above should be evaluated in further studies, at least to see how applicable they are to other situations and other contexts. Furthermore, these proposals imply that the facilitator needs to be sensitive to the attitudes in the workshop, to be able to administer remedial actions. Sensitivity to attitudes would thus be a critical facilitator skill for a scenario-building workshop. Moreover, having identified the attitudes of the workshop participants, this information could be useful to create a more acceptable system, in later design activities, and it would also potentially be useful to take these attitudes into account when implementing the finished system in the organization.

5.6. Conclusion

This research has shown that both the identity and the roles possessed by the members of an organization to a high degree affect how they want to use new and old technology for different tasks. By relating the attitudes to the participants' identities, and by using risk and benefit (with potential trust) as parameters to investigate the attitudes, we were able to explain the opinions and reactions. In the development and incorporation of new technology in organizations, the use of identities as a mean to analyze the user seems to be fruitful. The knowledge of what support, or threatens, the identity will not only make the technology use more satisfactory. It will also help to maintain the user identity and the community of use. It is therefore not enough, as often the case in technology development today, to focus on user roles; instead one should also acknowledge the importance and the difference of identity.

Although identity had a significant impact on the future workshops studied here, the card-based design session could be improved, taking
identity into account. We propose that a facilitator in a scenario workshop could benefit from being sensitive to participant attitudes. Having judged the general attitude of the group, if participants are too negative or too positive, a technology demonstration could show benefits or risks with technologies, to create a more balanced situation. Alternatively, the facilitator could give the role of critical analysis to one of the participants and the role of over-positive to another, alternating these roles between participants during the workshop. Also, a card labelled benefit/risk could be used to document design suggestions, which have been critically examined. That would preserve design solutions of which participants had reservations, information which can be important in further design work. These proposals could be evaluated in future research.

5.7. References


IFRA 2000. Tomorrow's news. Darmstadt, Germany, IFRA.


Organizational computing systems, Milpitas, California, United States, ACM Press.
In this study presented we investigated safety-related usability issues of an advanced medical technology, a radiosurgery system. We were interested in which criteria are important for users when a system’s usability and safety is to be improved. The data collection was based on interviews and observations at three different sites where the Leksell GammaKnife is used. The analysis was qualitative.

The main finding was that the user’s identity or professional background has a significant impact both on how he or she views his or her role in the clinical setting, and on how he or she defines what improvements are necessary and general safety issues. In fact, the opinion even of users experienced in safety-related problems was highly influenced by how they related to the technology and its development. None of the users actually considered Leksell GammaKnife as lacking in safety, instead, their assessment was directed towards potential future system improvements. Our findings suggest that the importance of user identity or professional background cannot be neglected during the development of advanced technology. They also suggest that the user feedback should always be related to user background and identity in order to understand how important different issues are for particular users.
6.1. Introduction

During the last decades, human rather than technical failures have been identified to represent the greatest threat to complex healthcare systems relying on advanced technology [Vincent, 1995]. However, the use of technology often reflects and influences the social context in which both the artifacts and their human users operate. This is even more the case in organizational settings where technology and users are highly specialized. Here, both task and social structure (where issues such as professional background and education are also of importance) are influenced and shape the use of technology.

Clinical visualization technologies can be regarded from mainly two points of view, viz., as the virtual presentation of the human body in a way identical to its natural counterpart or as an artificial human-computer interaction paradigm in which users are active participants within a computer-generated three-dimensional virtual world [Riva, 2003]. Barley [Barley, 1990] has looked at these technologies introduced into radiological work and investigated how they affect both tasks and the skills possessed by the users, however not with the focus of safety. The association between the technology and social structure has however only been touched upon in the context of concrete system development methods [Kyng, 1993], [Beyer and Holtzblatt, 1999]. From the viewpoint of clinical safety, this situation is highly unsatisfactory [Kohn et al. 2000].

The aim of this study was to investigate radiosurgery systems from the viewpoint of the relations between clinical practice culture, role, usability and safety. Usability methods are today commonly applied for safety evaluations of clinical computer systems with regard to the risk for errors [Beuscart-Zaphir et al. 2004], [Zhang et al. 2004]. However, as Barley points out, there are few tasks that are independent of the social context in which the work is carried out [Barley, 1990]. Furthermore, technical change in almost any context will in turn affect tasks, work and social structure (especially notions of power and
authority). It will also affect how the issue of safety is both perceived and dealt with professionally and institutionally. Thereby, a particular aim of this study was to investigate the two-way association between the users’ professional identity, the Leksell GammaKnife radiosurgery system, and safety issues. The users of the GammaKnife systems included in the study were either trained physicists or specialized and board-certified neurosurgeons. Previous studies have addressed safety and quality assurance in radiosurgery from the viewpoint of dosimetric and geometric accuracy [Scheib et al. 2004]. These studies suggest that the weakest link in the so-called chain of uncertainties is the stereotactic magnetic resonance imaging.

6.2. Methods

In this study qualitative methods were used for the data collection and the analytic work. This study was a part of a larger usability evaluation intended to identify aspects that would improve the usability and safety of a computer-based neuro-surgical tool. We studied a radiosurgical system consisting of two parts: the Leksell GammaPlan (LGP) software for intervention planning, and Leksell GammaKnife (LGK) for the radiosurgical intervention. The system developed by Leksell makes use of the ionizing potential of gamma radiation for the treatment of tumors as well as of arterio-venous-malformations (AVM) in the brain [Leksell, 1971]. LGK surgery is offered in many centers as an outpatient procedure. A decisive advantage that is often brought up by its users is the issue of accuracy, in that LGK allows the planner to perform a very precisely localized energy deposition such that it enables also the irradiation of very small volumes. LGP runs on desktop computers and the interaction with the software is through mouse and keyboard. To plan a radio-surgical intervention, LGP utilizes data from MRI images and/or other imaging modalities both to visualize the anatomy of the patient’s head and to localize the target volume(s) and further volumes of interest. The anatomical data can be visualized both in the form of 2D-slices or as a 3D-model of the patient’s head generated by using
the information in the slices. The planner defines the target(s) and eventually further volumes of interest by drawing contours with the mouse on the images containing the corresponding structures. Radiation iso-centers (an iso-centre is a focus point of a large number of beams, sometimes referred to as “shots”) are then placed inside the target(s) in such a way that the desired amount of energy is deposited in the target cells. The amount of dose one needs to deposit inside the target is a function of the size and type of lesion and of the location of the target and the tissue surrounding the target. The patient is placed within a MRI (Magnetic Resonance Imaging) unit and is fixed into position with the help of a stereotactic frame and a fiducial box. Sometimes other imaging types are used (e.g. CAT and PET) but MRI is the method which is applied most often. Because the fiducial marks are also visible on the MRI images, it is possible to locate and fix the tumor(s) in relation to the LGK. The operator of the LGP uses these images to do the surgical planning. This planning involves locating and fixing both the position of the tumor and the placement of the “shots” (size and duration of the radiation pulses). Later, when the patient is within the LGK for treatment, the stereotactic frame helps to place the patient in the iso-centric position that corresponds to the plan.

6.2.1. Data Collection

Observations were conducted at three clinics (two days at each clinic) and unstructured questions were asked during day-to-day practice at all sites. While the number of sites visited is small, in qualitative research we were not attempting to make general statements. Rather, we intended to (i) illustrate and (ii) explicate key elements of practice, in particular, to achieve a fair reading of “what is really going on” in GammaKnife clinics, a question, for which other orders of proof and validity apply than can be obtained from pure numbers.

In addition to field observations we performed also six in-depth interviews, two with physicists and four with neurosurgeons. These interviews lasted between 1 hour and 3 hours and were open-
structured and open-ended. The experience with LGK among the interviewed ranged from 3 to 36 years. At all three sites, the observer (Dinka) was introduced as a person who had no ties to the system manufacturer. However, the subjects were informed that results were to be delivered to the company (Elekta Instrument AB) as well as published in the research literature.

Every interview was audio-recorded and the material transcribed with accuracy true to level 2 of Linell’s transcription scale [Linell, 1994]. At this level of transcription every word, every restart of individual words and longer breaks are transcribed. The analysis was then made with the transcribed text together with the notes that were taken in the field. Quotes used in this article were translated and slightly modified were needed in order to be presented in comprehensive English.

6.2.2. Study settings and procedure

Observational studies were made at three clinics that use the Leksell GammaKnife and Leksell GammaPlan (March-May 2004). At the three sites, situated in two different European countries, neurosurgeons were involved with the patient from the beginning. They decided at admission whether the patient was suitable for LGK radiosurgery, even if they did not perform the actual intervention planning. In the clinic where the physicists did the planning, their work started when a patient was ready for the imaging procedure. The LGK was maintained (quality assured) mainly by physicists and radiographers and in none of the clinics surgeons or nurses were involved in the actual maintaining. During the quality assurance the main task is to check the precision of the LGK both dosimetrically as well as mechanically. Also safety issues are checked. In both countries where the clinics were located, the law states that there has to be a medical physicist in the department. However, it is not legally required that a physicist be present at every single treatment. In the present study, the procedure and division of work when handling the LGK and the LGP can be described in six
steps, which largely correspond to the general routine procedure also used elsewhere.

(I) Diagnosis – This was always done by a surgeon, often with the help of a radiologist who analyzed images of the patient. The surgeon decided whether the patient was treatable or not with the GammaKnife.

(II) Patient and frame - To hold the head in a fixed position and to define the stereotactic coordinate system, a frame was attached by sharp screws to the head in local anesthesia. This was always done by a neurosurgeon, sometimes with the help of a nurse or a medical physicist.

(III) Imaging - The analysis of the MRI images was often carried out with the help of a radiologist. The planners, the physicists and the neurosurgeons were all present at the MRI unit to indicate what pictures they wanted to use in the planning process. Sometimes images were acquired by the aid of other imaging technologies such as e.g. CAT (Computerized Axial Tomography) and DSA (Digital Subtraction Angiography) etc. The reason for using other imaging techniques than MRI could be that the patient had a pacemaker or other metal in his/her body that made the MRI unusable or that radiological information was required which can only be obtained by CAT and DSA. During the interviews and the observations only the application of MRI and CAT was discussed and used by the users whereby MRI was mentioned as the technique most often used.

(IV) Planning - In two clinics, the planning was done by neurosurgeons. In the third clinic, physicists performed the planning. The planning procedure was thereby based on anatomical images (using different imaging modalities) and these images (coronal, axial or sagittal) were either used individually or together to make a model of the patient’s brain. In the actual planning, the tumors and volumes of interest were identified using
radiological (MRI, CAT, DSA) images and a planner outlined the target for the intervention on the monitor screen. Then the planner placed iso-centers inside the target in such a configuration that the target was irradiated to the extent desired. Sometimes it was necessary to treat parts of the surrounding brain, also with shots, e.g. so as irradiate the entire tumor, even parts that might not show up on the images. This was also sometimes done to cut the blood flow to the target.

(V) Neurosurgical intervention – The interventions were carried out differently in the three clinics. There was always a physicist nearby but not always in the actual room. First the frame’s position was checked so there were no interferences or potential collisions between the frame and the LGK during the treatment. The actual treatment was performed differently in all three clinics. At the first, a nurse supervised the treatment. At the second, a nurse together with the neurosurgeon supervised the treatment. At the third, only a radiotherapist carried out the treatment since in that country the law states that only a radiotherapist is allowed deliver therapy with the aid of radiation.

(VI) Maintenance – As mentioned above, the LGK was maintained (quality assured) mainly by physicists and radiographer. Even if not a part of the actual treatment, this is an important step in the use of the LGK.

6.2.3. Data Analysis

The analysis of the interviews has been influenced in part by the Multi-Grounded Theory (MGT) [Goldkuhl and Cronholm, 2003]. In MGT, as in most qualitative research, observation and analysis both involve to some extent inductive coding where a set of phenomena, statements and concepts are identified as “central”. Since the present research dealt with usability issues, the phenomena, statements and concepts we were most interested in had to do with what informants had to say
in respect to technologies they used. As with all grounded theory, MGT is based on a theoretical model or set of assumptions. The only difference is the degree to which that model or the assumptions are made explicit or not and of course how “strong” the model or assumptions are.

The theoretical grounding used here included Barley’s [Barley, 1990] work that we used to show the link between identity, task and artifact. This set of linkages was extended with the work of Wenger [Wenger, 1998] and locked in this way to a particular community of practice. To get the historical perspective on localization and to relate neurosurgeons to their position (both social, but also to get an understanding of their identity) we used the work of Star [Star, 1989].

6.3. Results

6.3.1. Competence redundancy and safety control

The basic principle in view of safe clinical practices during the application of LGP and LGK was to ascertain redundancy of knowledge and competence. The upholding of the clinical safety essentially motivated the redundancy the physicists provided to the practice routines. Note how the following physicist deals with the issue of oversight and control when he talks about his role in MRI imaging sessions. He believes that accountability and responsibility has to be in one person’s hands.

“we follow the patients to the MR(I), and it all comes down to perhaps my total distrust of anybody else”

Quote 1, Physicist 1

The main reason for being skeptical to the LGK process becoming even more automated, another physicist told us, had to do with a
perceived loss of control. Control is important here because no one involved has “perfect” trust in everyone else’s competence and abilities. While the clinical practitioners value their autonomy, they are well aware that this autonomy can put them at risk – morally and legally. Generally the “risk” that professional autonomy raises in radiology had been dealt with by increasing quality procedures. The staff members also believe that issues regarding responsibility and autonomy would become “hidden” and thus not subject to review if the LGK process became highly automated. One important aspect here is however that the users were not negative to all automated systems; they just wanted to stay in control over their area of responsibility. Consequently, the neurosurgeons were positive to automating the areas controlled by the physicists, such as some of the control functions normally performed by the physicists, and vice versa.

The role planners described themselves to have with respect to LGP depended on whom you talked to and how the structure of their site was organized. Every site had a different mix of the experienced and less experienced users and different sets of working relationships existed at each site between the neurosurgeons and the physicists. This takes us back to the issue of trust between colleagues, but also in extension a trust to the program and to the machine. While trust is difficult to program, the ability to build, confirm and maintain it is central to almost all-professional, coordinated work. Practitioners often think of and deal with these issues as issues of quality in their daily work. Here, the more experienced users said they did most of their planning alone. The less experienced users, not surprisingly, reported just the opposite. They were also more likely to ask for help. However, we found that almost no one whatever his or her rank, profession or experience, made an entire plan on his or her own. While the level and kind of cooperation differed from site to site, even the most experienced users asked their colleagues for input:
“If any of the old members of staff were to sit at a planning console then they will almost certainly sit alone, and they [by themselves] will cope with the plan, ...[still] most of these time they would then go independently to the neurosurgeon and say 'I’ve got this plan do you like it?' Just occasionally if you have a situation where it’s a difficult plan and it doesn’t quite fall out...easily, then any of us would say to another experienced member of staff ‘What do you think, would you do any more to this?’ and they might say 'Well I might tickle that corner”

Quote 2, Physicist 1

Neurosurgeons and physicists justified the involvement of others in the process differently. The neurosurgeons often talked about validating the planning process scientifically. It was not just for them a clinical intervention but also an opportunity to add to the medical and scientific literature as well as to build up a database. The data collected would be used to establish LGK protocols as well as to help establish the validity of this approach to neurosurgery. Physicists sometimes would ask a neurosurgeon on site for a medical opinion. More often however, physicists asked fellow physicists not neurosurgeons to check their treatment plans to see if they could be improved. When interacting with the neurosurgeon they described their role in the process as that of being the “extra thinking person”. Their function, as the physicists saw it, was to be a kind of safeguard. When they supervised the frame fixation, they did this to ensure that the target was aligned properly for treatment and in general to make certain no mistakes are made. By knowing what constraints are built into the LGK regarding e.g. reach ability, the knowledge of the planning- and treatment process will come into use already during frame fixation. Aspects such as possible frame collision with the LGK during treatment can be avoided if the frame is correctly positioned from the beginning. Furthermore, because a physicist supervises the frame fixation, this qualifies him or her to be part of the planning process. This in turn insures that their opinions will be taken into account throughout the treatment process.
6.3.2. Perceptions of error or failure in Leksell GammaKnife radiosurgery

Note the way the following surgeon talked about precision and what the endpoint of LGK research should be:

"But we really have to ask the question differently... the question is not: Where should we have a greater precision? The question has to be clinical: What is my purpose? What do I want to achieve clinically?"

*Quote 3, Neurosurgeon 1*

A number of different event sequences were thus considered as suboptimal in the LGK treatment process. Physicists and neurosurgeons tended however to define these sequences quite differently. The same is also true when it came to the question of how to correct or to remedy them. Physicists defined both failure and remedy in terms of precision and “measurement”. For example physicists often defined failure as errors that lead to distortion (inaccuracy) of MRI images. Improving the system for such “failures” were synonymous with repair work that they often had to do i.e. erasing or minimizing errors “built” in the system. In short, for them failure largely had to do with lapses in precision and in the long run these errors could be reduced only by making the system more precise. When it came to the neurosurgeons, the question of what is a failure was more complicated.

For the surgeons, failure had much to do with whether or not changes in technology could “improve” neurosurgical therapy. In other words, failure can be defined broadly or narrowly and it is often locally defined. In short, what may be considered failure at one place or time in one context may not be in another. The point here is that failure for them had more to do with clinical “success” and repeatability i.e., that one success should lead to another and then to another and so on. In fact if
questions about failure were not defined this way, surgeons had little interest (and patience) with discussions about failure.

"You must first ask the clinical question, think about in what areas the radiosurgery is improving and then you have to ask how do you improve the radiosurgery and then you can move forward”

Quote 4, Neurosurgeon 1

Failure for these surgeons was an issue of identifying clinical needs and fulfilling the needs.

“So, if you start with the need, and then think about how can I move on to fulfill the need, rather than the other way around. [This is how]...you improve the machine”

Quote 5, Neurosurgeon 1

In other words, failure, as these neurosurgeons understand the term, is intimately related to praxis and treatment. It is also tied to issues of responsibility, accountability and competence, i.e., to clinical success. This is “measured” by the surgeons on a case-by-case basis. If there was any machine error, e.g. image “distortions” the treatment team, largely the physicists, were responsible for correcting them so that surgery could proceed safely and effectively.

The neurosurgeons thus took a different stance when it comes to “improvements”. The greatest improvement, from their perspective, has to do with making the process more scientifically valid and thus making every clinical GammaKnife decision and use be empirically grounded. The neurosurgeons also emphasized the need to have them involved in any future efforts made to “improve” the tool.
"What is still missing is (the knowledge of) radiation sensitivity for different areas in the brain and that is a development that we as users has to do, I mean we have to publish and do studies and so on”

Quote 6, Neurosurgeon 2

To improve these machines, neurosurgeons argued, not only do they have to be clinically effective, they also have to be able to provide scientific data that “proves” how effective this technology and surgery is.

"There are one thing that is needed and that would be great to have in connection to the GammaKnife and that is extensive radiobiology research. Knowledge that really go into the effects of radiation on the different tissues that you treat...so that you do not treat people unnecessarily”

Quote 7, Neurosurgeon 2

When asked, one surgeon explained that this concern with science and data led ultimately, to more effective forms of LGK radiosurgery. Given this belief, it is hardly surprising that neurosurgeons wanted “proof”. After all, the LGK surgery is a relatively new form of surgery whose efficacy is still discussed. Further, so far in the view of the neurosurgeons there has been little or no research on “which” LGK treatment “works best” for specific conditions. In other words, the protocols that are so much a part of modern medicine and surgery have not yet been established for LGK. Attacking this issue, making surgery more scientific was more important for the surgeons involved than any kind of “machine” improvements. The paradox here is that the concern physicists had with accuracy and precision could lead to the kind of scientific data that the neurosurgeons desired but they did not seem to recognize this. The fact that surgeons seldom “run” the machines themselves also makes these kind of improvements
(accuracy and precision) less important for them than the physicists. Here is what one surgeon had to say about this.

“If I’m going to answer that from a scientific point of view so to speak, you assume that you have a situation where you have maximum precision and you have a situation where you do not have maximum precision and you can compare the results. This is not possible within the GammaKnife society, there is no possibility to compare a bad treatment with a good treatment because in our terminology it is not visible if you have done a bad treatment or not, our terminology is so diffuse that you can hide many of the bad treatments, in theory anyway...”

Quote 8, Neurosurgeon 1

The surgeons sought to make the LGK process more scientific and empirical and they believed the system should have the functionality to help them achieve this. This of course was consistent with their desire to place both medicine and surgery on an objective and scientific basis.

6.3.3. Improvements and Safety

In general, all users were quite satisfied with both the LGK and the LGP. When the neurosurgeons were not satisfied with the LGK, the problems they experienced were comparatively trivial and related to the User Interface (UI). The more refractory issues they identified had to do with larger scale problems like “fit” between the organization they worked in and the technology they used. This often had to do with the “integration” of the LGK they used to other systems like MRIs or to other LGKs globally. In brief, there are some fundamental issues that LGK users pointed out that were not easy to resolve. For example, when asked about possible improvements to the LGK, we found there were significant differences between the neurosurgeons and physicists who were involved in LGK therapy. Several of the neurosurgeons participating in this study believed that the distance between the
developers and themselves had become greater. They believed that the “technicians” had essentially taken over the LGK’s development.

"When Leksell was in charge, I mean,.. no technician that...made any [judgment] calls, ...he decided every damn thing. The outcome then was that it was very user friendly, but now they sit in Linköping and they make stuff up and then they send it out for testing..."

Quote 9, Neurosurgeon 3

The frustration expressed here was not be shared by everyone in the GammaKnife community but we heard it more than once. This might be an artifact of the LGK’s history. Earlier on, when there were fewer users, every one of them played, they believed, a direct role in the instrument’s development. As the end-user pool and the firm itself have grown, the end-users we interviewed felt that the rationale for improvements have become more and more opaque.

"They just sit there in Linköping and invent something, and then it turns out to be a function that we don’t really want"

Quote 10, Neurosurgeon 4

The user here was referring to the general functionality of the LGK and LGP as an integrated unit. Again these opinions seem to be more about a perceived distance to the developers than statements about design features. Still, these new “improvements” made the machine more complex and harder to operate.

"...what I would like is that the electronics and the computerized stuff was more user-friendly, //, that the machine said, ‘If you want to do this, do this’, in plain comprehensible text ..."

Quote 11, Neurosurgeon 3
These improvements sometimes led to the machine being perceived as difficult to operate. At times machine operations seemed even incomprehensible.

"Then there are some combinations of keystrokes that you have to press, it’s up to three or four different ones, in a certain order, within a certain time, to make the GammaKnife reach parking position for example, and it is like taken from an old Witchcraft book”

*Quote 12, Neurosurgeon 1*

To equate keystroke sequences with what can be found in medieval charm books suggest, as we have seen above, that the perceived distance between developers and the firm and its users has in fact increased. Note that this is a perceived distance, not necessarily a “real” distance, instead this feeling might be traced back to the increasing number of users of the LGK that has created a larger organization. Further, but not surprisingly, these physicists and neurosurgeons have found different “problems” with the LGK. A quote from a physicist presented above makes this clear.

"I think GammaPlan is good software, it is in general very user-friendly, and much friendlier than other software products I’ve experienced so I’m always hesitated a bit to criticize something that is good, but one of the things that I don’t think is very good is the information that it gives to the physicist”

*Quote 13, Physicist 1*

The reason for this may be that from the perspective of the physicists, the improvements they required were within the actual machine, not the LGP, and that these improvements had much to do with precision and information representation. These issues of accuracy and precision, the physicists believed, are up to the manufacturer to improve. In fact, physicists believed that the main issue with LGK radiosurgery is that the issue of precision has been neglected by the
LGK industry. In fact, physicists told us it is the single most important issue the industry has to overcome. Important here is that the physicist did not consider the LGK to be inaccurate, in their view accuracy would be the main issue to make LGK even better. The neurosurgeons on the other hand did not emphasize this as a problem at all (see quote 4 for example). This “split” in opinion of course reflects the different roles each play in LGK surgery as well as differences in their professional training and socialization. For physicists coming from a “hard” science background tend to see issues related to the LGK as things that can be “fixed” only if some measure of precision can be introduced into the process. On the other hand, surgeons tend to see work with the LGK as something that occurs patient by patient, i.e., as a series of individual cases and projects. This is reinforced by how surgeons tend to practice “science”. What neurosurgeons look for is “same and difference” or “what works “best” for a particular disease or symptom group (this constitutes what they call a cohort). In effect, what these surgeons tend to value is something like history (which intervention works best over time). It also resembles natural history in that what the surgeons value and collect are comprehensive descriptions of both the singular and the normal examples of a disease. To the physicists, this often does not seem like science at all.

6.4. Discussion

The aim of this study was to investigate safety in LGK radiosurgery from the viewpoint of the relations between clinical practice, staff roles, usability and safety. We found significant differences between how surgeons and the physicists defined work, error and failure and how these factors together defined the role safety played in treating patients’ brain tumors with LGK therapy. Surgeons tended to focus on improvements that had clinical and/or scientific yield. The physicists, when they talked of error, did so in relation to the machine error, and those who wanted to improve the LGK were mainly concerned with improving the machine’s “technical” precision. We also found that
these differences were connected to how they thought about themselves. The identity of being a neurosurgeon or a physicists not only defined how they used the machines involved in the treatment, it also had a great impact on how they would define a successful treatment and how they defined what error is.

When neurosurgeons talked about making the procedure more accurate, what they meant had much to do with what they understood science to be. As they understood the term, science should “drive” innovation and change in clinical medicine. This in turn reflected the conviction that their role as clinician and scientist should be closely coupled. After all, they believed that to be more than “merely” a competent surgeon, one has to “do” science as well as clinical work. This could also be put in the light of how neurosurgeons have looked upon them historically and the identity that emerged early on in the development of the profession [Star, 1989]. The physicists, on the other hand, see themselves as more like technicians and problem solvers. As they understand their role in LGK therapy, it has much in common with a systems engineer because they are responsible for system maintenance and upgrades. Their background in physics plays a role in how they define intervention success – as ones related to the issue of precision.

If system designers were to build in the protocols that determine "safe" GammaKnife operation, and these could be, first, discovered and, second, covering rules for them written, its users would have found the GammaKnife system more "useful". It is not clear however whether this is possible. There may be no necessity in any case for integration in this system (or any other for that matter) of a one to one correspondence between machine rules and what users "can do" or "should do". While it is possible to write global rules and to specify in one form or another global rationality, doing so does mean that all local level issues (local rationality) have been handled or can even be addressed this way.
What is important is that representations reflect and make visible tasks and functions that end-users, not designers, find problematic. The identification of these problematic tasks and functions are, in its nature, connected to the user identity. Depending on how the user reflects upon his/her work will define what is considered as problematic. Also, these tasks and functions should be treated with respect to the user identity so that the understanding of actions matches the real actions taken. The point here is that what users consider often to be obvious is not necessarily where a problem lies. After all, when it comes to complex professional work, introspection is not the strongest guide to what in practice or thought is problematic for end-users themselves.

The other issue of course is whether a single set of representations, however robust, can support work that occurs in a heterogeneous workplace. This is a matter of transparency, if a representation is understandable for a user from a different user group then the target for that specific representation, the understanding might even increase for the whole process. In short, if a user can relate information and representation to his/her own work, the understanding of processes connected to the own work has a possibility to increase. However as pointed out above, end-users need support when it comes to bring their own representations and what they do that falls under the term work closer together. It is this ability to translate back and forth between various representational schemes that should lie at the center of any good design agenda. Too often there is an analytic distance that separates what we in the HCI community find out about end-users and what gets transmitted back to those who develop and build for them.

Having said all this, what advice can we offer about safety in LGK radiosurgery? For instance, the new DIN (‘Deutsche Industrie-Norm’) 6875-1, defines quality assurance (QA) criteria and tests methods for linear accelerator and GammaKnife stereotactic radiosurgery/radiotherapy including treatment planning, stereotactic frame and stereotactic imaging and a system test to check the ‘chain
of uncertainties’ [Mack et al. 2004]. Hence, to tell designers and developers that different users, given their different backgrounds, will think about and use the same technology differently would probably not surprise them. This would also not help them much when it comes to writing up design specifications. After all, designers and developers (and management) want to hear something more from us (but seldom do) than it just “depends”. The distance perceived by the users (as seen in quote 10) is most likely not only a distance in understanding of the software. Wenger talked about identification by non-participation [Wenger, 1998] that is a kind of identification that creates an identity by stating what you are not. In this case, one way of increasing the neurosurgeons’ identity for example as a scientist is to distance themselves from the developers. By indicating that system developers' practices are unimportant for the scientific process, clinical users may strengthen their identity as scientists, they will also strengthen their identity by positioning themselves towards what they are not, i.e. system designers. The question then is where does the responsibility for patient safety lie and more importantly how to make certain these issues get addressed in product design and development.

In this study, we found that professional identities and how “success” and “improvement” are defined influence safety in the use of the LGK. In particular, we have displayed how practical work with the LGK rests on and validates for the neurosurgeons and physicists involved quite different understandings of what science and “experiment” are. This raises the question of how much we really do know about designing machines and applications for collaboration and communications in groups that are not homogenous. While the medical informatics literature to some extent recognizes that sameness and difference exist in every workplace, the consequences in view of how we should design and develop safe technologies has seldom been addressed in any explicit way. The medical informatics literature also has had little to say about how to build artifacts to support groups of heterogeneous professionals whose work has, at least theoretically, the same
endpoint. To answer the question of why these differences in the approach to clinical computer systems occur and matter, one has to take things like competence and professional socialization into account. These issues - what sources that in reality are used to inform clinical work and how prior experience and training play into this - have seldom been discussed in the medical informatics literature.

6.5. References


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7. The Need for Transparency and Rationale in Automated Systems


As medical devices and information systems become increasingly complex, the issue of how to support users becomes more important. However, many current help systems are often ignored or found to be too complicated to use by clinicians. In this article, we suggest an approach that allows designers to think about user support and automating tasks in ways users find more acceptable. The issue we address in particular is the notion of transparency and to what extent it allows the end-user to understand and critique the advice given. We have found that one central problem with existing support systems is that often the end-user does not understand the differences between the automated parts and the parts that have to be done manually. By taking aspects of transparency and control into account when designing an automated tool it seems that some of the more refractory issues that help systems pose for professional users can be addressed.

7.1. Introduction

When creating complex medical devices and information systems, efforts to create automatic user support are seldom given high priority by the industry (see [Grudin, 1996]). The result is that end-users are
unable to derive full value or benefit from the application, no matter how “good” or “well designed” it is. The need for competent support can in particular be seen among accidental users, i.e. users who are forced to interact with the system not because they want to, but because they have no alternative [Marsden and Hollnagel, 1996]. These users have an increased need for support features, and vendors therefore more often provide such aides. However, the irony is that the more the industry recognizes a need for support systems and tries to provide these, the clearer it becomes that support tools embedded in most applications are seldom, if ever, used. Grudin [Grudin, 1991] has previously analyzed such “lack of fit.” The help systems were considered ineffective because end-users seldom found that the built-in support fitted their needs at any particular moment in time. Dealing with tools used in professional situations, the issue of “matching” support to user needs becomes even more critical. A typical example is those medical expert systems that were designed to “imitate” the diagnostic process more than support physicians’ efforts to arrive at a particular diagnosis. By imitating the process, there is a risk that the flexibility present in traditional diagnostic processes will be lost [Forsythe, 1996, 1999, Nyce and Graves, 1990]. The physicians may instead get a false impression of security and confidence.

A problem when automating tasks is that users lose some or all control over these tasks [Dreyfus and Dreyfus, 1999]. The importance of user control was already in 1987 emphasized in the guidelines used for product development by Apple Computer [Apple Computer Inc. 1987]. Even though the views presented in those guidelines have been criticized by Genter and Nielsen [Genter and Nielsen, 1996] and further discussed (e.g. [Lindell, 2004]), the issue of control is both important and largely unresolved. For example, there is no clear consensus yet regarding how to determine how “much” either the user or the machine should “control.”

Suchman for example talks about how expert help systems for a variety of reasons have been designed to support an activity that should be
easy to understand in the first place [Suchman, 2003]. For some reason, expert systems tend to be designed this way, i.e. without taking the intuitive and contextualized decision-making process into account (see [Graves and Nyce, 1992]). If help systems are designed to support tasks that the users find comparatively easy to perform, clearly the extent to which expert support systems can “help” becomes more limited. Furthermore, as Suchman points out, there is a risk that the support that such systems offer “ends” before a task is completed. This of course undermines whatever creditability a help system might have for its users. The question then is how to build support systems that can address an operator’s need for advice from start to finish and as a task becomes more and more complex. These issues have been discussed in the literature on user support and agents. However, there, the discussion has tended to centre on the issue of trust. In short, while these discussions have been going on for some time (see [Maes, 1994]), the question of how to handle the problem outlined here has not yet been resolved.

The aim of this study therefore is to investigate the problems and obstacles clinicians have with automated support in the use of medical devices and information systems. A vendor may supply any number of reasons for why a system performs (or has to perform) as it does. What we wish to discuss here is a different set of issues, which have to do with user perceptions. In particular, we will discuss how users perceive the tasks they perform (from simple ones to more complex) and the kind of support an automated help system can give to the users (weak to strong) in relation to these tasks.

7.1.1. Methods

We will use the Leksell GammaPlan (LGP) and Leksell GammaKnife (LGK) system (manufactured by Elekta Instruments AB, Sweden) as the basis for the analyses. The system consists of LGP, which is a program mainly for planning radiation treatment of, among other things, brain tumors. The planner (a neurosurgeon and/or a medical physicist),
sometimes together with a radiologist, uses imaging technology, mostly Magnetic Resonance Imaging (MRI) to identify targets within the brain. When the planner has identified the targets, the images are imported into LGP. In the LGP program the planner “marks up” the targets. The marking procedure consists of the planner drawing lines, using the mouse, around the target in the different views (images) presented on the screen. After identifying and marking up the images the planner places target fields of gamma radiation (size and dose) over these images and the program calculates how the different fields of treatment will affect each other. These fields are represented on the computer monitor by lines in the cordial, axial and saggital views of the brain. These are also available as small 3D representations where the fields are represented as spheres. Users can adjust dosages for more sensitive tissue, such as the eyes. They can also indicate (mark) areas, which should receive minimal radiation, i.e., risk areas.

In the LGP, the support system, called the Wizard, is designed to help the user with the planning process. The Wizard was included in the LGP as a response to market conditions: it was designed and implemented to give Elekta a competitive edge. After defining or outlining the targets, the user can ask the Wizard to fill each target with a specific radiation iso-dose. The user can decide whether if the Wizard should fill in the target with many small shots or a fewer number of larger shots (in the sense of area size). The application has a built-in sliding scale users can move from many to few shots. The Wizard then calculates the size and strength of the shots and places them within the marked area. The user is presented with the result as a finished plan. If the user is not satisfied with the plan, they can adjust every single shot, but the reasoning behind the shots is not visible to the user so it can be very hard to know the effect one shot has on another. To put it another way, the user has to decide if the plan as presented is “good enough,” if not, the user will have a hard time identifying each shot’s “role” within a specific plan.
This research used both observations and interviews. The data collection was performed at three different clinics that use the LGP and LGK, two in Sweden and one in Great Britain. Every visit to a clinic started with field observations, where the physicists and the neurosurgeons were observed using the LGP. Planning activities were observed as well, such as visits to the MRI and staff talking to patients. During the observations, participants were asked about their work. They were also interviewed as they used the system. Field notes were taken throughout the observation time. A structured open-ended interview was done with some users; these were performed in the physical surroundings of the LGP and LGK whenever this was possible. In all, six interviews (each lasting 1 to 3 hours) with four neurosurgeons and two physicists were conducted. The participants were selected to represent a variety of GammaKnife experience (between 3 and 36 years) and a broad range of training and education for both physicists and neurosurgeons. The interviews were audio taped and transcribed using Linell's second level of transcription [Linell, 1994]. At this level of transcription every word, every restart of individual words and longer breaks are transcribed. The data collected was qualitative and its analysis was derived from the transcribed text along with field notes. The material was coded and central phenomena, statements and concepts were identified and related. The next step in the analysis was inspired by Grounded Theory [Glaser and Strauss, 1967; Strauss and Corbin, 1988; Goldkuhl and Cronholm, 2003]. According to these methods, the analysis is always brought back to the collected data. Issues, statements and concepts that were identified as central were derived directly from field data. When certain statements led to more abstract statements or concepts, the field material was consulted again to see if these structures were grounded in, or “inferred” directly from the material. This kind of contextually driven inquiry draws its analytic strength from the interplay between field material and conceptual structures and the more general statements that emerge from it.
7.2. Results

7.2.1. User Experience

In the daily planning work, neither the medical physicists nor the neurosurgeons used the Wizard at all. The Wizard in fact was only “opened” and used when new users were introduced to the LGP. All study participants’ educated new LGK users, either by traveling to sites where the LGK was to be installed or by teaching new users at their home site. In these situations, the participants felt obligated (they told us) to show the Wizard to new users, but they seldom recommended it to them. The Wizard was, in this context, shown to users as part of the LGK “toolbox.” However, when they showed new users how to create patient plans, they never used the Wizard. In this way they made a clear (and negative) statement about the Wizard’s value and their negative experience of the Wizard was thereby transferred to the new users.

The reasons behind not using the tool have much to do with issues of professional competence. As one informant explained, the Wizard did not manage to address the right issues (at the right time) to be a useful tool. A medical physicist suggested that the Wizard only automated the easy tasks, the things that are easy enough to do yourself. It did not help the users with the interesting things, those things that are problematic, complicated and time consuming.

Furthermore, by handing planning over to the Wizard, informants said, makes the second stage in the planning process, editing the shots, even more complicated. When users construct plans, they also build mental maps to be able to locate the shots with reference to the images. By using the Wizard, the clinician ostensibly abandons the responsibility for some of the most critical decisions involved in planning of LGK surgery; i.e., where to place the radiation shots. In addition, when editing a plan the Wizard has created, the user has no
clue of the significance or rationale for each shot. Nor does the Wizard indicate how each shot relates to the other.

"You lose control and you lose your way, certainly if you use the wizard, if you produced a plan even with a large number of fields somebody comes to you and says where is field 6 you usually have an instinct where that field is, if the wizard has produced it, you have absolutely no idea where field 6 is, and you have to find it, then you don’t quite know what it is doing and so you do lose control...”

Quote 1, Physicist 1

What “gets lost” with the Wizard is the contextual knowledge of spatial relationships in the brain that the clinical users have acquired over time and apply to these shots. The Wizard connects the images and shots and formulates a plan in ways that are not necessarily visible or intelligible to the clinician. To put it another way, the Wizard’s "actions" do not seem to reflect a plan or to have a rationale. This is in part because nothing like a plan is made visible within the Wizard. Further, the Wizard’s actions cannot be disputed nor challenged by an operator. The issue we raise here is one of representation, how machine action is represented to the user. However, the issues that the informants brought to our attention were not limited to this. Nor is representation reducible to transparency (which machine action is visible to users). The issue here is also the one of control. Some of the participants were skeptical about whether all the steps involved in planning could be automated. This is because they believed that it is close to impossible to record every step a clinician takes while making a plan. One of the physicists stated:

"I think the problem is that there are too many decisions to be made. It’s a very demanding process, the planning process, and there are always decisions to be made along the way, that are not easy to document,“

Quote 2, Physicist 1
There are two reasons for this. First, many cognitive and mental steps are needed in each plan because the key elements are statements about relationship(s), i.e., how each target, shot and image are linked together in some reasonable, intelligible way. In short, not only is each step in a plan complicated to arrive at, the data needed for the choices to be made are hard to acquire. Physicist 1 perceives in other words, both the plan and all elements that go into a plan, as complicated to generate, record and reconstruct and therefore almost impossible to automate, regardless of how “strong” a support system may be in technical terms.

What is at stake here, as the clinicians see it, cannot be reduced to an issue of trust as the term is generally used, (see [Nyce, 2005]). In other words, the most important question is not whether the Wizard can do the “right” thing. It would also be unwise to regard the users’ concern about control as some kind of unjustified Luddite fear of automation. What is really at stake here is whether if the clinical planner can “plan” without opening up the plan’s rationale or logic for discussion and subsequent revision. This is what the Wizard neither allows nor enables and this is what these clinicians point out when they talk about loss of control.

Furthermore, some of the steps in a plan involve sequences that are very hard to get “right,” even for highly trained staff. This makes it difficult to both elicit and compile rules that could automate the process. End-users believe that these steps include the identification process where the images are interpreted, e.g., when the tumors are identified. This process, given that tumors (and other potential targets) often take irregular forms, can be very complicated and for this reason it is not uncommon that several specialists and planners often have to work together "to get things right". This raises the issue of how to elicit and “build” rules for automated systems when decisions in practice result from collaboration across disciplines.
The lack of functionality described above illustrates not only the problem of creating a support tool for professional users. It also suggests why end-users find such a tool difficult to use and/or trust. This reluctance is not because of a lack of help functions, but rather because of the way the help system is structured, modeled and implemented. In this case, what help the system provides has almost entirely to do with the first steps in the process – steps that for most users require little support and are regarded by the users as relatively unproblematic. The LGP provides little or “flawed” support for later steps in a plan, i.e., the more complicated and time-consuming parts of the planning process. One informant puts it this way:

“Editing its actually difficult... the program tends to develop a life of its own, and making small changes to a contour can be tricky...”

Quote 3, Physicist 1

Rather than actually enable the work at hand, we could argue that machine support, as it is presently designed here, disrupts what for end-users is difficult work, as well as challenges their ability to make the right decisions. The result is that this machine support can slow down, rather than enable, the planning process. It is clear that the help embedded in the LGP may not be as useful as it possibly could be, given the process and how operators generally work up a plan. One informant made this point when talking about how one element of Wizard support not only “gets in the way” but also becomes an obstacle to building a plan:

“But some things they have placed so that you as a user will recognize the system as intelligent. [But this] can also lead in the wrong direction. [For example] when it automatically chooses the shot that is closest, right, and that can be quite irritating...”

Quote 4, Physicist 2
In contrast, other users believe that some of the planning tasks could be relatively easy to automate. An example of this is when the planner maps out radiation doses and tumors as a series of smaller spheres (doses) within a larger sphere (a tumor),

“I mean, what you would really would like to have [for]...this is a computerized planning function, //, because then...[there would be nothing left that would be hard [for an operator] to do, other than the indication adjustments”

*Quote 5, Neurosurgeon 1*

The question here, at least from this user’s perspective, is that if one part of the process is easy to automate, why not take the next step as well and automate the entire planning process? Since the user does not see the technical problems that developing and implementing such an automated process would entail, he takes the next “logical” step and envisions a planning system so automated and easy to use that it would not require specialists to operate it.

“If you do the improvements that I’m talking about, then you would have a nurse system. Then you have a doctor who is doing the framing, if you think that pounding a nail in the head is a specific physician thing to do, then it would not be on a difficult level, but there are traditions, and then you have a doctor who draws out the target and the rest would be nurses work.”

*Quote 6, Neurosurgeon 1*

This neurosurgeon is not suggesting that nurses operate the system as it is, but rather he asks whether it would be possible to bring into the clinic a planning system so easy to use and so automated that a nurse could handle it, without any additional training. Users like these, here exemplified by nurses, would not require the kind of transparency medical physicists and neurosurgeons require. For physicists and neurosurgeons to use and trust an automated system, they must see, understand and be able to correct every action that the machine takes.
But for users like nurses, this neurosurgeon believes that if the system is designed correctly, it could work automatically with minimum demands upon users and certainly without having the kind of transparency built in that neurosurgeons and physicists require. What this neurosurgeon is suggesting could lead to a redistribution of workplace tasks and competence that could have implications beyond the planning process itself. This could be labeled as “deskilling” or “reskilling,” depending on one’s position in the workplace, with all the symbolic and political consequences these terms carry.

7.3. Addressing the Problems

Each time a planning process begins, the Wizard, because it provides help (from an experienced clinician’s perspective) at the wrong time using the wrong terms, can be interpreted by the users as questioning, or second guessing their judgment and competence. This occurs in particular when the Wizard submits a plan that has too few or too many shots. Furthermore, when the system suggests solutions that are not “good enough,” it provides users with “proof” that it is not trustworthy. And, if an experienced user sees the Wizard’s “help” as providing help only with the easy aspects of the planning process, the disjunction between user and application grows even wider. In these ways, the Wizard brings to the surface issues of competence and professional autonomy. Operators see its use as both threatening and as a waste or loss of time. The risk here is that this distrust of the Wizard will “spill over” into other parts of the help system, especially other automated parts. It was not long ago that, for example, the Automatic Position System (APS) was introduced to the LGK. With the APS the operator no longer needs to enter the LGK operating suite and adjust the patient’s position manually after every shot. The APS can do this automatically. Nevertheless, even though the APS has a flawless record (and is used very frequently), users often see it as making both the LGK and LGK therapy itself more complicated.
"There are many who thought that the APS, when it came, was a shame because you lost your skill. I mean, the new LKG became an incredibly simple machine to use; it was just like a screwdriver. Ok, the planning was one thing, but I mean the actual LGK, I mean it would work [flawlessly] all the time, there was hardly anything that could go wrong.... "

Quote 7, Physicist 2

This perceived loss of control is why many operators at some level distrust the APS procedure. They “correct” its perceived “lack” of reliability by checking and double-checking the positions that the APS will use in every therapy. This distrust is not manifested here (as with the Wizard) by disuse (not using the system at all) but rather each time they use APS it adds to their workload. (Staff believes it is necessary to double-check and re-check all APS actions to guarantee accuracy and patient safety). While the APS may be a more “rational” and efficient way to move patients through therapy, once again the issue is one of transparency. For users, action and activity as represented in the APS is only weakly connected to what goes on during actual LGK therapy. In short, as with the Wizard, when transparency becomes an issue for users, it is often talked about by users in terms of control and loss of control. Again, APS has a flawless safety record. Nevertheless operator distrust persists and this can be traced back to a perceived loss of control.

To understand why this is the case, we need to take another look at the help system. The Wizard provides a user with little or no means of orientation. Therefore, it is hard for users to link shots to targets or a series of shots to different views of the same target. Essentially, the Wizard provides few reference points by which a user can “check” the solutions the Wizard comes up with. The patient’s orientation is more visible in the APS system, but for end-users the Wizard and the APS system raise the same set of issues. The reason for this has much to do with how these users both plan clinical interventions and think about
planning. With the Wizard, the reasoning or rationale behind a plan or solution remains invisible, not subject to either first ("I believe this is correct") or second orders ("We all also agree") of validation. Or, in other words, a user can neither validate the plan nor discuss or correct it with colleagues. Not knowing or understanding the rationale behind the steps the Wizard takes leads to end-user skepticism and even the belief that however “well” the Wizard may work, there is no coherent, logical plan that underlies its mechanical actions. It is the perceived absence of what one informant called a philosophy that especially makes users doubt the advice and plans the Wizard provides.

"You have to learn what the philosophy of the plan was. If there WAS a philosophy, and you don’t get to know it because it is buried in the mathematics somewhere, and even mathematicians probably don’t know what the philosophy of that particular plan is, you lose control. Now, I think that would be acceptable - we would all accept the loss of control if the automatic methods were producing a much better solution and obviously a better solution. The difficulty is that in both the automatic segmentation and the wizard, you lose control and do not get a better result”

Quote 7, Physicist 1

The work connected with plans and planning is from one point of view impossible to automate. It is an interpretative practice premised on local rationality and a social calculus that balances available competence, possible plans and local resources in a way that makes it possible to both write plans and to get the job done. The work that is particularly hard to “rationalize” and automate are those steps in the process end-users talk about as “getting a feeling for the situation” and “getting to know the tumor.” This work is, in essence, an interpretation of the MRI images and targets, something far more complex than a simple “matching” of image to object. Rather, it involves understanding what the linkage between image and thing “means” and even if operators never use the term, this is interpretative work of a high order.
Because this is interpretative work, it raises the issue of how much “planning” and “plans” can be reproduced by mechanical action. The central issue here is whether any systems representation of the user and the work they carry out can match the view the user has of both. Embedded in the Wizard is a set of rules and procedures that reduce the target to only a sphere that needs to be filled with smaller spheres. For the planner, who, among other things, has to take into account not just the target but the tissues that surround each target, answering questions like “what is going on here?” and “what needs to be done next?” is a complex, interpretative process and one that is refractory to description as a set of rules or procedures. What a clinical planner does cannot be easily reduced to a series of decisions about the number and size of spheres and where to place them. Nor is it easy to “build into the equation” the role that differences in identity, goal and priorities, say between neurosurgeons and physicists, play in planning and the actual plans themselves.

7.3.1. Control and Ownership

A typical way to handle the issue of user support is to automate some, if not all, of the procedure that has to be performed. This not only reduces workload but can also provide “checks” that can theoretically at least reduce operator error. However, if we automate any part of the planning procedure, then once again the issues of ownership, control and transparency will come to the fore.

A plan does not actually become a plan (a series of LGK machine actions) until it is imported into the LGP. This particular sequence of events can raise a number of issues about ownership. The first is that every patient who undergoes LGK surgery “belongs” to a particular doctor. What is meant by ownership here is a way of talking about who has both the final word (approval) and control over each specific step in the process.
While the initial diagnosis involved only the patient and their doctor, this diagnosis is only the first step in planning for LGK therapy. Once a patient has been referred for consultation and possible GammaKnife surgery, additional data is collected (new MRI scans made) and often a new or revised diagnosis emerges. Every decision related to a patient’s plan is based on this new information. Essentially, the ownership for the patient shifts from the referring physician to the radiologist who “owns” the MRI scanner and the right to interpret MRI images. While the referring physician can give input and read (interpret) MRI images, as soon as the patient’s MRI scans are imported to the LGP, the patient (to be more precise a representation of the patient derived from clinical data and MRI scans) ownership shifts again and the clinical planner, not the radiologist or the referring physician, becomes responsible for the patient and his/her plan.

Throughout the planning process, while a planner may ask for help from their colleagues or query the radiologist regarding a specific issue, ownership stays with the planner; it is “his” plan. What ownership means here is:

1. A planner makes the final interpretation using the data on hand, and

2. If there is to be any further negotiations or discussions over what this data “means” it is because the planner has asked for them.

In brief, as the patient is “handed over” from professional to professional, this involves something more than a “simple” transfer of information about the patient. With these handovers, not only do information, ownership and responsibility for the patient “shift” but also all three have to be re-negotiated again. No matter how “unproblematic” a particular transfer may be, these shifts of ownership (and the right to interpret clinical data that accompanies these shifts) are:

1. not things most designers of support systems take into account, and
7.3.2. The Issue of Control

As we have argued above, the issue of control is important in this workplace. This became obvious, when analyzing the interviews and observations, but users themselves also express it explicitly on several occasions (as seen in Quote 1). To be more specific, the negotiation of “handovers,” i.e., the transfer of control and information, and the subsequent redefinition of who has ownership as well as responsibility for both the plan and the patient is something the Wizard does not support at all. The Wizard offers little or no support especially when it comes to the issue of control and how control is defined, redefined or negotiated as operators build a plan.

In planning without the Wizard, an operator builds up, makes use of, and refers to a kind of global map (a plan not just start to finish but a representation in which contingencies and the possibility of repair are or can be built in). Through this cartographic work, a planner exercises control, ownership as well as responsibility for what a particular plan “looks” like. To put it another way, a planner at the same time builds a plan for action and in reference to this map, defines particular risks and benefits as well as priorities.

In effect, to build a plan means working as a cartography of tumors (those issues of space, distance and location) and building (prioritizing) an essentially linear timeline or series of clinical and mechanical (LGK) actions. The Wizard, as it is now, can neither represent nor reproduce for end-users these two kinds of action nor the plan itself. Further, when the Wizard “plans,” an operator will encounter difficulties revisiting this plan or any of its elements whether these are related to map or action. In addition, with the Wizard, the reasoning that “drives” a plan, balances risk against benefit, one action against another, is hidden.

Information in the planning process is also property, property which different end-users at different points in the process have ownership.
Ownership does not have as much to do with property rights (as it does say with land), as it has to do with the right to “make sense of” information that is available at different points in the planning process. Initially, the radiologist both “owns” and “interprets” MRI images. Here “ownership” has more to do with "rights" than anything else, the right to make sense of information at a particular point in time, whether it is tangible or not.

Once these images are transferred to the LGP, and a clinical planner puts a note on or draws a line on, i.e., interacts with, the MRI image, the image becomes a plan. From this moment on, a planner, not the radiologist, “owns” the plan and the plan is referred to by that person’s name.

When and how ownership shifts in the planning process differs between physicists and the neurosurgeons. It reflects differences in identity, personal history and in professional socialization. It is also informed by the roles and responsibility both have, respectively, throughout the entire planning and treatment process. Neurosurgeons, while they “track” what goes on with a patient from admission to recovery, tend to intervene, i.e., take control and ownership directly only during the therapy itself. Physicists, in comparison, tend to be involved in planning and treatment from start to finish. The roles they have in both planning and a patient’s course of treatment also accounts for why they make different, and sometimes conflicting, demands on the Wizard, on what it represents, how it should “work” and what kind of control it should or should not have on LGK therapy.

7.4. Discussion

The aim of this study was to investigate the lack of use of automated support, and more specifically this use with medical devices and information systems in a clinical setting. We found that one central problem with existing support systems is that the user does not understand the differences between the automated parts and the parts
that have to be done manually. The Wizard was efficient in planning parts that were not perceived as difficult by clinicians. Nor is there any visible indication of the differences between these two kinds of operations (manual/automated) and their results (in our case, plans). For example, an end-user cannot compare the plans (made manually or by the machine) along a particular axis or variable, such as precision. For the operators this raises at least the question of why the entire process cannot be automated. What is not obvious to end-users, of course, is how difficult it would be to design, build and implement an automated support system that can replace the whole manual process safely and efficiently. Since this is beyond the scope of what is feasible, when it comes to the question of the Wizard and what to do next, the vendor has some not very fortunate options to chose from. One is to build a product line into the future without automated support. But to remove “features” in a competitive market could put a vendor at a disadvantage. Another option might be to open up the automated support system for end-user inspection. But representation of a complex process in terms that may or may not be intelligible to operators raises its own series of problems and issues. Another option, and one that may have more merit than the others, is to increase the transparency of the automated process.

7.4.1. Transparency

While we cannot overcome the lack of fit between machine rules and human action, [Suchman, 1987], we can address the issues this raises through stronger, more analytic, research and design cycles. A way to attack the problem is to work more carefully on the issue of transparency. To achieve “transparency,” designers of a system need to make their understanding of this planning, their implicit and explicit models, accessible to end-users. However, it is not enough to make both the planning process and the reasoning behind it visible to the end-user. End-users must also be able to “inspect” and change and challenge these models in the development cycle. Furthermore, end-
users should be able to adjust and change these models on the fly as their work and competence(s) change and evolve over time. In a sense, the end-user should be able to negotiate the actions taken during the LGP planning process, either alone or with colleagues. It must also be possible to intervene, i.e., halt or change, the process on the fly and at the same time represent and document these changes. It must be emphasized that this transparency does not need to be “real” in the sense that all machine actions have to be represented as they occur. What does need to be represented is each step, its place and significance in the planning process, and the process itself and these all need to be depicted in terms the end-users can understand. This will enable the end-users to negotiate and claim ownership of a plan. It will also “open up” a plan for discussion and debate. The intent here is to reengineer the Wizard so that it functions as something other than a conventional help system. Transparency, as it is meant here, would offer the potential for the Wizard to be redesigned so that it:

1. functions to some extent as a collaborator, and
2. provides resources and information that support and enable collaboration among all the parties involved – regardless of the differences in their roles, their training and the claims they may make regarding ownership, competence and authority

7.4.2. Design Suggestions

Today, the Wizard in the LGK system does not address the needs of the neurosurgeons or the physicists who use it. Neurosurgeons cannot see how tasks the Wizard “solves” relate to any clinical outcome. Physicists worry about ceding control to the Wizard when they traditionally are responsible both for the planning process and the plan itself. To overcome issues of this kind, it may be necessary to redesign the participatory elements of the design process so that issues of identity, role and differences in responsibility and competence can:
1. be addressed, and

2. connected to the design, development and implementation effort.

The initial phase would involve users together with designers in a design agenda that would focus on what a "plan" is in GammaKnife surgery and what in this context does it mean to "plan". Other competences, like ethnography could be brought in to help “uncover” the tacit, implicit aspects of a plan [Dekker and Nyce, 2004, Nyce and Bader, 2002]. After all, the HCI literature makes it clear that end-user introspection alone does not result in strong or adequate design [Graves and Nyce, 1992]. Also, the extent to which a skilled professional can “remember” let alone “account for,” or rank the significance of the work they do everyday remains an unresolved issue in the literature [Forsythe, 1999].

A design agenda of this kind might start with dilemmas that these practitioners have the most difficulty with. For example, the question of how the Wizard might handle margins, those intersections between tumor and normal tissue that are fuzzy and not well defined, might be one of first the issues to be taken up. To address this in a scenario, a user would mark (as partly done today) the areas that need to be protected. The second step would be to mark the actual tumor. Then the Wizard could go in and fill the tumor with shots. To make the step easy to follow, it should be possible to “back track” every shot so the kinds of actions taken by the machine can be inspected and, if necessary, critiqued and changed. This would help the users to both take control of and “buy into” into both the design process and its (automated) results. Again the issue is how to translate both the terms and consequences of machine initiated action into terms end-users are both familiar with and “make sense” given where the end-user is in the planning process. For example, planning at different points in time in process has much to with the control of “shots” and iso-doses, and these differences in scales and unit need to be addressed and accommodated. Another issue, perhaps the most difficult one to
resolve, is how ownership and action “go together” in the planning process when both can be defined and thought about quite differently given the end-user. "Adjusting" shots is not as important for neurosurgeons as providing resources that enable the kind of work and collaboration that lead to clinical success. In contrast, for the physicists the issue of “shots” and support has more to do with ensuring that the plan “drives” the machine actions (that of the LGK itself) as accurate as possible.

7.4.3. Summary

The Wizard was not used, mainly because:

- It automated relatively easy tasks, not the problematic, complicated and time-consuming ones
- The work after the Wizard was used became more complicated because planners had little confidence in its results and, to address clinical and safety issues, had to do "after the fact" repair work

This leads to the question of what can be automated. The participants felt that it would be hard to transfer the LGK planning and treatment to something that is “rule-based,” as an automated process by definition is. There is also the issue of automation or replacement. If one part was possible to automate, why cannot the rest be automated? The reason users were skeptical of arguments re: automation has to do with control, process and trust. In order to address these concerns when creating an automated process, this research suggests that the most important issue that needs to be addressed, but rarely is, is how to give the user sufficient access and control of the process to ensure the user will trust it. This is not an affective statement but rather one about confidence in the adequacy of the machine action, [Nyce, 2005]. This also has to do with making the process transparent and intelligible to the user. Further not only does the user have to understand the reasoning behind the decisions made in the automated process, the
user should be able to interrogate and change, as needed, both machine actions and how they are represented.

7.5. References


This study investigates how the clinical use of visualization technology is formed by the users’ prior experience and training. More specifically, this study investigates how role and professional identity are associated with the use of visualization in GammaKnife radiosurgery. Data were collected through observations and in-depth interviews at three clinics using the Leksell GammaKnife®. Data were analyzed using qualitative methods. The users’ professional autonomy, their ability to perform interpretive operations themselves, was found to be reduced each time the visualizations were in disharmony with their understanding of clinical reality. The main issue for the users was a lack of transparency, i.e. a black box problem where incomprehensible algorithmic representations “stood between” or “in the way of” the task(s) they wanted to perform. From the viewpoint of a neurosurgeon, transparency means not being forced to take any additional step that would be in contradiction to his/her previous experience in traditional surgery. From the viewpoint of a physicist, every step that can possibly cause a loss of mathematical
precision creates a distance from what is experienced as clinical reality, even if clinical reality is only measured with an apparatus. In conclusion, designers have equated or confused metaphors, here transparency and toolkit, with interpretations of the “real” from the viewpoint of different professional groups. As medical informaticians, we have not recognized that former metaphors, the transparency rhetoric, have come more from ourselves than our informants.

8.1. Introduction

Clinical visualization technology is currently used in a broad spectrum of clinical settings and has attracted many categories of professional users. In practice, several user groups often interact with the same visualization systems. On the one hand, the various user groups represent differences from a task-oriented perspective; users have different goals when interacting with the system. On the other hand, users who have been appointed to solve the same tasks with the system may also have significantly different professional backgrounds. While the medical informatics literature addresses the issue of collaboration, the division of labour associated with the introduction of new technology has not received the attention it perhaps requires. In the case of visualization technology, this situation is unsatisfactory. Recent reviews suggest that the operating room of the future will be an integrated environment with global reach [Marohn and Hanly, 2004]. Surgeons will operate with three-dimensional vision, use real-time three-dimensional reconstructions of patient anatomy, use miniaturized, minimally invasive robotic technology, and will be able to telementor, teleconsult, and even telemanipulate from a distance, thus offering enhanced patient care and safety. Regarding the design and development of systems with an even distant resemblance to such integrated environments, attending to issues related to cooperation and practice cultures will allow us to develop more efficient technologies for the clinical workplace. Most importantly, however, these issues of cooperation and practice culture will help developers and end-users to
deal with issues related to “same” and “different” that are present, but generally not acknowledged, in almost every clinical workplace.

The aim of this study is, therefore, to investigate the clinical use of visualization technology as formed by what each user “brings to the table;” his/her prior experience and training. Specifically, this research examines the mechanisms by which role, identity and profession influence the use of visualization in gammaknife radiosurgery.

8.1.1. Background

The history and development of neurosurgery has been, to a large extent, technology driven. This is quite different from neurology, where even today there are reports of resistance to “abandoning” things that have worked well in the past. [Star, 1989] What we find in neurosurgery is, however, not some kind of lockstep between technology and practice. It is more of a feedback cycle where technology and practice influence each other and together define and drive what is constituted as “best practice”. In this context, a professional identity is a way of describing who we are through talk and action. This identity reflects, and can be modified by, the social contexts and structures within which we work. [Wenger, 1998] In every part of creating this individual identity, there is also the concept of distinguishing oneself from what one is not. Wenger calls this phenomenon identification by non-participation. Identity then frames not only self, but also thought and action. Interaction with artefacts can here lead to changes in a clinical practitioner’s identity by adding experience and thereby changing professional history. This study focuses on the role identity plays when using visualization technology when planning a particular kind of surgery (the use of gamma radiation to treat tumours and malformations in the brain). Visualization technology may, in this setting, be seen as having a direct impact on skill, task and context. However, these effects are not necessarily direct. In fact, indirect effects can be as significant for operators as direct effects. Barley makes this clear:
Technologies are depicted as implanting or removing skills much as a surgeon would insert a pacemaker or remove a gall bladder. Rarely, however, is the process of technical change so tidy. Page 67 [Barley, 1990]

8.2. Methods

Qualitative methods were used for data collection and analysis. The application used in the study was a radiosurgical system based on two parts: the Leksell GammaPlan (LGP) software for intervention planning, and the Leksell GammaKnife (LGK) for the surgical intervention. The principle is to use gamma radiation to destroy tissue; LGK is used for treating tumours as well as other non-functioning tissue in the brain. There is no need for open surgery and the patient is able to leave the hospital after a short time. LGP runs on a desktop computer and interaction is through mouse and keyboard. To plan a neurosurgical intervention, LGP utilises data from MRI (Magnetic Resonance Imaging) and/or other imaging modalities, both to visualize the anatomy of the patient’s head and to localize the target volume(s). The anatomical data can be visualized both in the form of 2D-slices and in the form of a 3D-model of the patient’s head generated by using the information in the slices. The planner defines the extent of the target by drawing contours with the mouse on the images. Radiation iso-centers are then placed inside the target(s) in such a way that the desired amount of energy is deposited in the target cells. The amount of energy required to deposit inside the target is a function of the location of the target and the tissue surrounding it. The anatomical information is normally acquired with the aid of MRI. During the entire procedure, a so-called stereotactic frame is attached to the patient’s head, and because certain parts of the frame are also visible in the MRI images, it is possible to locate the target(s) in relation to the frame. The LGP operator uses these MRI images to perform the surgical planning. The treatment-planning step involves locating the position of the target(s) and determining where the “shots” of radiation (size, duration, and strength) are to be placed. A “shot” is the dose distribution created by irradiating a small volume of tissue by a large number of (in the case of LGK, 201) beams. Later,
when the patient is in the LGK for treatment, the stereotactic frame helps place the patient in the positions that corresponding to the plan.

8.2.1. Study Settings and Procedures

Observational studies were conducted at three clinics that use the LGK and the LGP methods, two in Sweden and one in the UK (March-May 2004). Neurosurgeons were involved with patient management from the beginning at all three sites. The neurosurgeons decided at admission whether the patient was suitable for LGK radiosurgery, even if they did not perform the actual intervention planning. In the clinic where the physicists did the planning, their work started when a patient was ready for the MRI. Mainly physicists and radiographers maintained the LGK system. No surgeons or nurses were involved at any of the clinics. Here the main task was to check the precision of the LGK system; that the dose rate measured in LGK was the same as the dose rate calculated and used by LGP. There were also controls that had to be checked regarding safety issues. In both countries where the clinics were located, law required that there was a physicist in the department. However, a physicist was not required by law to be present at every treatment. In brief, the procedure and division of labour when handling the Gammaknife and the Gammaplan can be described in five steps.

1. Diagnosis – This is always done by a surgeon, often with the help of a radiologist who analyzes the patient’s images. The surgeon decides whether the patient is treatable or not.

2. Frame fixation – This is a frame attached with sharp screws to the head used to hold the head in a fixed position during imaging and treatment. This is always done by a neurosurgeon, sometimes with the help of a nurse or a medical physicist.

3. MRI - The analysis of the MRI images is often carried out with the help of a radiologist. The planners, the physicists and the neurosurgeons, were all present at the MRI unit to indicate which images they wanted to use in the planning process. Sometimes
images were made from technologies other than MRI, such as CAT (Computerised Axial Tomography). This is done when a patient has a pacemaker or other metal in his/her body that contraindicates the use of MRI.

4. Planning- At two clinics (the two in Sweden), the planning was performed by neurosurgeons and by physicists at the U.K. clinic. At one of the Swedish clinics, a physicist assisted the neurosurgeon during the planning, even though the neurosurgeon did the actual interaction with the LGP. The planning procedure is based on anatomical images and these images (coronal, axial or sagittal) are either used individually or together to make a model of the patient’s brain. In the actual planning after identifying the targets on the images, a treatment planner outlines the target(s) for the intervention on the monitor screen. Then the planner places iso-centers (an iso-center is a focus point/volume of a large number of beams) inside the target in such a configuration that the target is irradiated to the desired extent.

5. Neurosurgical intervention – The interventions were carried out differently at the three clinics. There was always a physicist nearby but not always in the actual room. First, the frame’s position is checked to ensure that there are no interferences or potential collisions between the frame and the LGK during the treatment. The actual treatment was performed differently at all three clinics. At one, a nurse supervised the treatment. At the second, a nurse together with the neurosurgeon supervised the treatment. At the third, in the UK, only a radiotherapist could carry out the treatment, since according to UK law, only a radiotherapist can deliver therapy with the aid of radiation.

8.3. Data Collection

Observations were conducted for two days at each clinic. Unstructured questions were asked during day-to-day practice at all sites. The
observer (Dinka) participated during the planning, image gathering (MRI) and treatment of patients. Also, the observer participated in staff meetings and discussions with patients and discussions between the planners, such as when a planner had a difficult case and sought advice and second opinions. In short, the observer participated in all five steps described below.

In addition to field observations, six in-depth interviews were also conducted, two with physicists and four with neurosurgeons. These interviews lasted between 1 and 3 hours, were open-structured, open-ended and started with the participants providing a description of the procedure. From these descriptions the interviewer discussed positive aspects and possible negative pitfalls of the described steps. The open-structured interview also touched on subjects such as personal history (educational and clinical experience), relations to technology in general and usability issues regarding the GammaKnife system. Experience of LGK among the respondents ranged from 3 to 36 years.

At all three sites, the observer (Dinka) was introduced as a person who had no ties to the system manufacturer. However, the subjects were informed that results were to be delivered to the company as well as published in the research literature.

The interviews were audio-recorded and the material transcribed with accuracy true to level 2 of the Linell transcription scale [Linell, 1994]. At this level of transcription, every word, every restart of individual words, and also longer breaks are transcribed. The analysis was then conducted with the transcribed text together with field notes.

8.4. Data analysis

Methods based on Grounded Theory (GT) [Goldkuhl and Cronholm, 2003], [Strayss and Corbin, 1998] were used for the analysis. In GT, as in most qualitative research, observation and analysis both involve, to some extent, inductive coding where sets of phenomena, statements and concepts are identified as “central” [Strauss and Corbin, 1998]. In
this study, the concepts and statements were categorized in three dimensions: hardware/software, level of importance, and area covered. These categories were elicited from the data through a qualitative analysis of the transcribed interviews, as well as with regard to the notes taken during the observations. The area covered category was chosen as the main dimension, because it involved subjects that the participants either came back to several times or empathized during talks. This dimension included potential problems, potential solutions and general discussions of functionality. From these categories, the following sub-categories were formed: Integration, Positioning, Optimization and Organization.

Even though the main approach is inductive, even GT is informed by theory. Barley’s theories [Barley, 1990] form the basic theoretical grounding employed in this study, which is used to convey the linkages between identity, task and artefact. This set of linkages has been extended using the theories of Wenger [Wenger, 1998] and locked in this way to a particular community of practice. Moreover, to represent the community of neurosurgeons from a historical perspective, the history of localization and evidence-based medicine as described by Star [Star, 1989] was related to the collected data. The primary research process thus involved data collection, data categorisation, structuring of the categories with regard to each other, relating the resulting constructs to the theoretical grounding, and finally comparing results with the data collected.

8.5. Results

8.5.1. Visualization in radiosurgery

All LGP sites made use of anatomical representations of the brain. Derived largely from MRI, these images are the planner’s main information source. As one physicist put it:
"Doing the planning you are blind, you just got the images."

*Quote 1, Physicist 1*

The problem is that there is much here left for the end-user to interpret. While every picture “tells a story” the story it tells here is seldom a straightforward one. When it comes to LGP surgery, the story (diagnosis, treatment plan and prognosis) emerges from discussion and debate. To put it another way, images, individually and collectively, are evidence and evidence has to be interpreted in order to make statements about “what is really going on here” and “what needs to be done next.” Neurosurgeons believe that there is a profound difference between open neurosurgery in which you can actually see and touch the brain, and work with the LGP where this is not possible. In a traditional open surgery setting, it is easier to see what others involved in the treatment do, since it is directly visible to the eye. In LGK surgery, the actual LGP partly plays the role of a colleague, with the important difference that action taken by LGP and LGK is only visible via the screen. The consequence is that the belief held by neurosurgeons that the “laying on of hands on the patients,” is the benchmark of “real” clinical work. It needs to be pointed out too that visualization (reading the image) is not so much a process of inspection (a literal, direct reading of an image) as it is a process of interpretation. This rests of course on the operator’s prior experience and competence in linking together, at a particular time and place, “textbook” knowledge of neuroanatomy, the patient’s history, the results of his/her laboratory tests and whatever images a planner has at hand. What the Gammaplan gives users is a representation of a “brain” derived from digital MRI “slices.” These images represent the major part of the information that the surgeons and physicists have of a patient’s brain and target(s); tumour(s). Of course the neurosurgeons and physicists also have the patient’s clinical history and summaries of whatever laboratory work that has been done on the patient. Besides the MRI images, there is also available to LGP users a small 3D representation.
of the patient’s brain. What is striking is that despite the strong claims advocates of scientific and medical visualization for 3D, these operators seldom refer to or make any use of the LGP’s 3D representations.

“When you use and you are an experienced user, you have the 3D image in your head, you don’t need any software to see it, I mean that is the way you have to think if you think about it in a surgical point of view, even if you are thinking from an anatomical perspective, at least that is how I feel...”

Quote 2, Neurosurgeon 1

This may be an example of one of those things competent operators can do “better” by themselves. As regards medical instrumentation, this raises the issue of whether we are designing and implementing what for end-users could be the “wrong” thing (for a discussion of this point, see [Star, 1990]). First, it is not clear whether or not we know enough about how 3D work is embedded in clinical and scientific competence. Nor is it clear if we understand how the 3D representations and operator competence link and work together to provide a plan for clinical action. What we do know is that these end-users believe that the information provided by MRI images of the brain is more complete and accurate than any 3D representation. This, it seems, has something to do with these users seeing digital slices as “closer to” the biological reality of the brain than any 3D representation derived from brain slices can ever be. To put it another way, with MRI “slices” only one set of operations is performed on the images. But to arrive at a 3D representation, another set of operations has to be performed. While both the MRI brain images and the 3D reconstructions are derived from (the same) machine operations, with the 3D reconstructions there is yet one more experienced “black box,” another set of algorithmic operations and this, it is believed, further separates users from the biological reality of a particular brain. There could of course also be an historical aspect to this, that the users are trained to analyse in 2D. However, the impression given by the users in this study does not support this
historical approach. Nevertheless, even if the 2D/historical perspective is true, the opinions expressed above, regarding 3D, should be taken into account.

8.5.2. Transparency

What the users of visualization technology seem to have believed was that their professional autonomy, their ability to perform interpretive operations themselves, was diminished each time there is yet one more step “removed” from biological reality. To put it another way, the 3D representations provided by LGP were not seen as “transparent” or literal. What this means, here, is that they are far removed from any literal representation of the thing itself. It also refers to the fact that end users cannot “match” their own understandings of how a 3D image should be “built up” and what it should look like against how the LGP’s “black box” produces these representations. Nor can the neurosurgeons and the physicists involved inspect, challenge or change the rules (algorithms) that are responsible for the form the generated LGP take. In brief, the considerable autonomy and authority these users derive from being able to make valid statements about brain and patient are threatened by the (second order) representations. The same can also be said to be true about whatever claims these end-users make regarding their own competence as physicians and scientists. These opinions were even more obvious during the observation at the clinic where the physicists were doing all the planning.

Transparency, in this context, also refers to the fact that 3D models can only present the surface of a target and from this a planner cannot easily “build up” a picture of the tumour itself.
“You can’t plan this in 3D because you don’t see 3D, you just see the surface of a 3D volume and that is why, and then you are not able to... you have to see the whole of the 3D volume and that is only possible when we slice up a 3D volume and look at it slice by slice.”

*Quote 3, Neurosurgeon 2*

In contrast, when several slices are placed side by side a planner can see both the tumour’s contours as well as the area of the tumour that is to be covered by a certain iso-dose surface. Nevertheless, MRI images have also become one of the bottlenecks in the process. This is particularly true when it comes to the issue of precision. As used now, MRI images, physicists believe, have come to represent in terms of precision at least the law of diminish returning. Neurosurgeons do not emphasize this lack of precision, instead they use knowledge about the existing precision in a traditional clinical way so that they can relate the treatment in focus to previously known treatments.

“This is like a chain, we know that we have a certain precision here, we have a precision here and then we have a certain dose that we empirical know that we have to give taking all the previous known precision into account, and then we do it”

*Quote 4, Neurosurgeon 2*

This quote raises the question of what the staff defines as a successful treatment. In turn, this will bring into focus the kinds of changes these neurosurgeons and physicists believe would improve the success rate of LGK surgery.

8.5.3. Visual Translation for Clinical Validation

Often transparency is equated with applications and/or hardware that can adapt to individual users, given each user’s background and needs at a particular time and place. [Star, 1990], [Star, 1992] However,
transparency means something quite different to the end-users in this study. Transparency refers to what the practitioners think of as a black box problem; that algorithmic operations and representations “stand between” or “in the way of” the task(s) they want to perform. This pertains to how to interpret MRI images so that the costs and benefits involved in LGK surgery tip in the patient’s favor. We can argue of course whether this transparency is “real” or an artefact (merely another kind of representation). However what matters in this context is the kind of transparency end-users want; one that is conceptually different from traditional surgery forces the neurosurgeon to take an additional step away from his/her previous experience. From the viewpoint of the physicist, in contrast, every step that might cause loss of mathematical precision creates a distance from what is experienced as “real,” even if these steps are only measured with an apparatus.

For example, neurosurgeons and physicists were unable to “open” the black box of the LGP 3D brain reconstructions. In other words, staff could not “get to” (inspect) the rules that governed how these representations were “put together” given the evidence (a patient’s MRI slices) at hand. Note that this does not necessarily imply that the practitioners wanted to challenge or change these rules. What they wanted instead was an opportunity to inspect these rules and to see which assumptions informed the rules and how this information related to the practitioners’ previous knowledge, either to traditional surgery or to the calculation methods previously used by the physicist. The practitioners wanted to compare how these representations were constructed with how they, from the viewpoint of their professional background, build up and make sense of these images themselves. This does not involve a problem with the MRI images themselves, because what the images “meant” to the practitioner was largely self-evident, or rather the constraints built into the MRI system were known. Further, the practitioners believed that it was easy to discover situations when the constraints were not self-evident. It is worth noting that while the LGP 3D models were seldom used in planning, these models were
often used with good results to illustrate the planning process and resulting plan for patients. This further confirms that “transparency,” what it means and what it should represent is very much a function of who the audience is.

Therefore, transparency should not be immediately equated (although it often is today) with a demand for a toolkit that end-users can use to “reach into” and “change” the black box that constitutes the computer-generated 3D image. The research suggests that it may be sufficient for users to inspect and understand why representations of information that these users work with takes the form they do. What each specific user group wants to know is to what extent the representations they have to count on to obtain complex, often problematic work done agree with what their own experience, training, and competence tells them. And furthermore, this group wants to know what these representations “should look like” and what they should mean when making specific clinical decisions.

8.6. Discussion

Considering that the operating room of the future has been suggested to become an integrated environment with global reach, the aim of this study was to investigate how the clinical use of visualization technology in gammaknife radiosurgery is formed by the users’ prior experience and training. We found that transparency was a central issue concerning the end-users, but that the different user groups defined the term differently. When trying to apply these results to the design of visualization technology, the importance of identifying more user aspects besides only their tasks becomes evident. By taking into account what different users “bring with them” to the workplace in terms of, for example, competence and professional socialization, designers can avoid building design functionality that is not important to the actual users. In our data, an obvious example is the 3D model embedded in the LGP that, in its current design, fails to take into
account how these end-users integrate images, knowledge and clinical findings to make a statement about what needs to be done next for an individual patient. The task for designers then, while seemingly one that reflects common sense, is to avoid building in functionality that particular user group finds to being trivial, “non-important,” self-evident or “easy” for them to do themselves. Identification of the actual and relevant categories a particular community of end-users falls into, with regard to both task and professional identity, will lead to a better investment of time, money and competence and, consequently, will result in more effective clinical use of visualization technology.

If system designers were to build on the basis of these issues associated with transparency, not only would the visual technology become more useful for these users, but their understanding of the tool would increase as well. Transparency, as indicated above, does not necessarily imply a need for a one-to-one map between the physical and its virtual representation. What is important is that representations reflect and make visible tasks and functions that end-users, not designers, find problematic. The other issue of course is whether a single set of representations, however robust, can support work that occurs in a heterogeneous workplace. The physicists’ identity helped them to define the role they played in the process, but also equally important the roles they did not play. They acted as problem-solvers and at each site the physicists tended to form a strong community of problem-solvers. This factor reflects their long commitment and training with experimental apparatus, apparatus that is seldom reliable and often has to be “nursed” along. It also reflects how they are trained to think about science. In a word, “improvements” of laboratory “machines” leads quite naturally to both scientific and more reliable knowledge. In short, science means something quite different to physicists than what it does to neurosurgeons. For neurosurgeons, it is clear that machines can lead to stronger clinical and scientific results. However, the question of what is “better” (more precise, more accurate) as physicists understand the term does not concern them
much. For the surgeons, science rests not on experiments per se but rather on comparative case-by-case work. The use and understanding of science, among surgeons, has always been pragmatic. No matter how “pure” or “good” science is, a surgeon will almost inevitably ask: What does this mean for my patients and how I do my work as a surgeon.

The issue of transparency can be addressed at least in part by asking representative target groups to test the system and to be part of the development effort. However, enlisting such target groups is not sufficient. Equally important are the kinds of questions these groups are asked to address and the kinds of questions that should be avoided. Among these might be how does (or should) visualization technology enable surgeons and physicists to work together to successfully perform surgery, and how does it support clinical or scientific research. To obtain this support the information connected to the practitioner’s task becomes comparable to making visible available information about what others do in the process. Knowing what roles the others play in the process will not only define the practitioners’ own role, it will also make it clear what the practitioners are able to do and the amount of trust that can be shared. The situation everybody wants to avoid is when a lack of transparency leads to information falling between each respective profession’s areas of responsibility.

The clinics included in this study were chosen partly because of the homogeneity in the users’ educational background. Therefore, the results cannot be immediately generalized to other settings where visualization technology is clinically used. A case study approach was used to point out aspects of possible interest based on the qualitative data analysis. More research is needed to be able to conclude if these assumptions and findings are applicable to other gammaknife sites worldwide, and to other applications of visualization technology. By choosing countries with educational similarities, we have tried to minimize the bias from differences in the training neurosurgeons receive. Moreover, by recording differences between the clinics in
clinical culture and work routines during the analytical process, a potential bias from the perspective of organizational differences has been taken into account.

In conclusion, a kind of category confusion was discovered – one that equates transparency and toolbox vis-à-vis the development of visualization technology. We suggest that what stops us as designers from delivering what end-users “need” is not just partial or incomplete knowledge, as medical informatics research maintains. Nor does it reflect an inability to move from knowledge and interpretation to vendor requirements. Rather, what end-users need stems from misunderstanding how the different professional categories talk and think about visualization technologies. We have equated or confused metaphors, here transparency and toolkit, with interpretations of the “real” from the viewpoint of different professional categories. In this context, the latter refers to those literal representations of clinical reality, derived from clinical practice, which accurately can tell us what we need to build. More importantly, we have not recognized that the former metaphors, the transparency rhetoric, have come more from ourselves than our informants.

8.7. References


9. Adding Value with 3D Visualization and Haptic Forces to Radiosurgery - A small theory-based, quasi-experimental study


This study investigates the use of 3D representation and haptic technology in radiosurgery. The users, experienced users of the Leksell GammaKnife, prefer the 3D representation for constructing a first draft of their plan for neurosurgical intervention. When it comes to the final adjustments, however they still choose the traditional 2D representation and interaction devices. The perceived control over the radiosurgical process is not considered adequate using the 3D interaction methods. Practitioners do not consider the haptic forces implemented in this test system useful. Possible explanations for these findings are discussed in the paper.

9.1. Introduction

It has long been established that when advanced technology is created, the design of the man-machine interaction should be a central
aspect of the development process. The design of interaction devices specifically adapted to the human user was first initiated in professional settings, such as in the aircraft industry. Later this became an important part also in the development of consumer products. In the human-computer interaction field, recent developments have, on the one hand, attempted to optimize the components of the traditional graphical interface, e.g. modifying graphical input devises (GIDs), (e.g. [Berglund et al. 2004], [Ibrahim et al, 2001], [Ingmarsson et al. 2004]). There have also been improvements in the graphical representation on the screen [Lindell, 2005]. New interaction paradigms have also been introduced, such as 3D interaction and representation. The 3D interfaces are often viewed as one of the most promising technologies for the next generation of human-computer interaction environments, especially in collaborative settings [Smith, 2005]. For interaction with a 3D representation, GIDs have been introduced that combine different existing concepts, e.g. a conventional mouse and keyboard. However, GIDs that allow the user to move more naturally in three dimensions have also been developed, e.g. the space mouse [3Dconnexion, 2005].

The development of interaction technologies has often been driven by a desire to demonstrate quantifiable system efficiency or effectiveness (e.g. Fitts law oriented studies like [Accot and Zhai, 2003] among others); there are also studies that take user opinions and satisfaction of users into account [Ingmarsson et al. 2004]. By focusing on increasing efficiency and effectiveness, the developer can have an objective benchmark test of how different design solutions compare to each other. However, it is not certain that a theoretically or quantifiable more efficient technology is superior to its alternative in real life. For instance, if the users experience that learning a new technology is too complex, then it will not be adopted. There are text input methods that are faster and more efficient than using the QWERTY-keyboard [Zhai et al. 2002]. One of the reasons that these alternative input methods are seldom disseminated is that the skills required to use the QWERTY solution are widely spread and learning a new input technology is
considered as too time-consuming. In short, developing for efficiency need not be the same thing as optimizing user adoption.

9.1.1. Study aims and context

Ways of interacting with computers that were impossible just a few years ago have now become available, technologically but equally as important, economically, for developers, for instance the use of 3D representations. Both from a visual perspective and from an interaction point of view, better hardware and software make it possible to visualize and work with 3D objects with a decent resolution and reasonable time flow [Smith et al. 2005]. Today, we also know that the use of technology in a professional setting is influenced by how the users position themselves in relation to the technology. The reasons for this can be found both in how the users present themselves in their practice, and how they are identified in their relation to the community they are part of [Wenger, 1998]. In a professional practice, the users’ identities and roles thus influence not only their interaction with new technology, but also their interpretation of what is an acceptable outcome and their view of how, quality, as one example, is defined (Dinka, Nyce, Timpka. The Importance of Professional Roles and Identity in Clinical Visualization System Design. Submitted 2005 to International Journal of Medical Informatics).

The aim of this study is to investigate how clinical users use and experience interaction with 3D representations of the human body and a GID involving haptic force feedback. 2D interaction methods are used as the baseline, and the investigation is conducted with regard to both system impact and user satisfaction. Clinical radiosurgery is used as the reference setting for the study. The Leksell GammaKnife (LGK) is a clinical radiosurgery system that uses radiation to neutralize targets, such as tumors, in the brain. By concentrating a high dose of gamma radiation on specific targets, the target is destroyed by energy. To be able to implement these interventions, the procedure is in present clinical practice planned using 2D body representations managed in
specific software (Leksell GammaPlan (LGP)). In the LGP the planner, a physicist or a neurosurgeon, make a plan that consists of the dosage information (the distributions and volumes of the target and surrounding tissue/critical structures) and the necessary intervention. The plan in the traditional LGP is structured around traditional 2D representations of the brain from MRI, CAT-scans or the like. For this study, a test system was built in which the users were able to construct and test an actual dose plan in a 3D environment. The system consisted of dose planning features; many of them similar to features found in the LGP software used for dose planning with LGK, and were connected to a Reachin Display. The Reachin display is a system consisting of one 3D GiD (called a Space Mouse), a haptic GiD, and a monitor with a mounted semi-transparent mirror and a special pair of glasses that, together with the monitor, give the user a sense of operating in a 3D world from the same position as if they were working with their hands. This implementation is intended to address the problem of just seeing the surface of a 3D object, instead of seeing an actual 3D object. In addition to the space mouse, which allows the user to navigate the object of focus in 3 dimensions, the equipment allows the user to experience feel and touch in a 3D environment. By having an additional GiD, a pen-like robotic arm provides the user with the experience of
being able to touch, grab and drop objects in a 3D environment (the Haptic Device in Figure 11). The feedback that gives the user this sensation is implemented by having forces in the robotic arms (the Haptic Device), depending on how strong the forces are and in which directions, the user gets a haptic experience where the use of haptic is defined as experiencing the sense of touch, and more specifically, the perception and manipulation of objects using the sense of touch [Oxford, 2005]. For instance, the potential to implement and perceive different forces can be obtained by programming the density of an object. An area in a 3D scene is given a certain density that is then transferred to the robotic arm when the user moves the pen-like GID (here called a Phantom) over this area. This will give the user an experience of touching the object and also “feeling” it through the Phantom.

Two forces were implemented in this system; one was implemented as the negative normal of the target surface. This means that the force tried to keep the GID inside the target surface. The other force was calculated from the dose distribution and tried to make the GID avoid areas of already high dose, so-called hot spots.

![Figure 12](image1.png)  ![Figure 13](image2.png)
One function that was added to the test system implementation but which was absent in the traditional GammaPlan was real-time dose-line changes in 3D. This made it possible for users to see how the isodose lines change in real-time over the 3D representation, i.e., the user could see how each shot placed on the scene would effect the surroundings by the way the isodose changed (the dark areas in Figure 12). In the existing LGP, the one used daily by the trial’s subjects, the isodoses are visible on the MRI images and are updated in real-time (the thin lines beside the target in Figure 13). Isodoses are information given to the user about the spread of radiation. In brief, by seeing the isodose lines, the user knows how the radiation will spread to its surroundings.

9.2. Background

In related research [Dinka et al 2005:3] the problem of 3D representation on 2D screens has been discussed. The main issue this kind of representation raises is that the representation does not show “true” 3D in the sense that it does not give the user an experience of interacting with 3D representations. (Note that this is oriented towards the representation, the actual object of focus may be 3D and experienced as 3D by the user.) The issue here is that the user only perceives the surface of a 3D object. Even if this issue could be addressed by letting parts of the object be visible transparently, the result does not seem to be satisfactory. It can even be argued that the traditional 2D representation, when slices of an object are presented on a traditional screen side by side, gives the user a “more true” experience of a 3D object since several slices presented side by side give the user the possibility to see more or less the entire object at the same time. (Dinka, Nyce, Timpka. The Importance of Professional Roles and Identity in Clinical Visualization System Design. Submitted 2005).

It is also more difficult to interact in a 3D environment than in a 2D environment. Traditional GIDs, like the mouse and keyboard, were
developed for a 2D interaction space, so there is no obvious and
natural way to extend GIDs to 3D interaction. When adding an
additional dimension, not only the aspect of knowing what the user
sees becomes an issue, but there are also issues of navigation and 3D
understanding that need to be addressed. Using a GID in 3D
interaction has to take both navigation and orientation into account.

With technology improvements and developments, the potential to
extend the use of GID and to incorporate new ways of interaction,
away from the traditional use of mouse and keyboard, arises. This
potential can be found in both soft- and hardware. Usage can be
increased by improving, or changing, the representation (software) and
in the actual interaction (hardware like GIDs or screens). When it comes
to GID, interacting in a 3D space requires, first of all, an extra
dimension of freedom in the GID compared to a conventional mouse.
With a GID, the user can move in all three dimensions at the same time.
With a 2D GID, like a conventional mouse, there has to be an added
input to move in the third dimension. That is, since the traditional
mouse only allows movement in two dimensions, the third dimension
must be handle by some other action. Often this is solved by using the
arrow keys from the keyboard or the like to add this extra dimension of
freedom. Another way to solve this problem is to provide users with a
tool that has all three dimensions of freedom built in, i.e. a GID that
allows the user to move back-forward, up-down, and in-out with one
move.

9.3. Methods

A quasi-experimental design that integrated quantitative and qualitative
methods was used for data collection and analysis [Shadish, et al.
2002]. The study data was collected during a medical convention.
Clinical impact, use patterns and user experiences were measured
using a combination of system interaction records and by collecting
data directly from users.
9.3.1. Evaluation prototype

In the test setting, study participants performed three different dose plans, with three different MRI sets of images from real patients with similar tumour formation and risk organs nearby. The graphical part of the interface consisted of a toolbox (on the left), a 3D representation (in the middle), and 2D MRI images (on the far right) (Figure 14).

Figure 14: The visual representation of the GID is in the middle. The target is in the centre, the corresponding areas in the MIR representation are also visible.
When the target is marked out in the LGP, it is possible to filter other information and just show the target. In the view presented here, the isodose lines are visible and put in context by the representation of the target (Figure 15). The overview, provided as a 2D representation of the MRI, is always visible on the far right.

9.3.2. Data Collection

Five subjects; four medical physicists and one neurosurgeon, completed a full test. This included three complete plans, one on each system. These plans were chosen to be similar to the plans that users encounter every day. There was also the potential to complete a shorter test of the system and fill in a short questionnaire regarding use.
The shorter test was more of a touch and feel test in which users were able to test the system for a few minutes and then fill in a questionnaire. Three neurosurgeons and one physicist filled in this questionnaire. We used data from the system in both settings to evaluate its potential. The participants came from Europe, the USA and Asia, and were all experienced users of LGP and LGK.

9.3.3. Data Analysis

Data analysis included a qualitative and quantitative analyses of the data from the full and the short tests. The two test systems were compared to a reference plan, conducted in LGP by the participants. The test system should not be considered as a new version of the LGP, instead it is an explorative system independent of LGP.

A quantitative comparison of clinical impact was conducted using Dose Volume Histograms (DVH). DVH is used in the existing LGP to visualize how the dose is distributed over a volume, and in real-life practice clinicians use DVH to evaluate the accuracy of their plans.

A qualitative analysis was performed to organize test results from the different sub-analyses in a grid-like model. In one dimension, there is the 2D, 3D and haptic force technologies. (From an historical perspective, we can say that there is also a 1D since the first versions of the GammaPlan did not have visual representation of the treatment, however this is not covered in this study.) The grid’s other dimension includes the issues raised in the interviews and questionnaire.

9.4. Results

9.4.1. User Experiences

The clinicians were most positive about the 3D environment without added forces. This interface was believed to make it possible to quickly create a rough first version of the treatment plan. However, for the final planning, the participants still preferred to use the 2D representation of
the brain. An important reason for this choice was that they were not sure about the accuracy of the more complex system, including the haptic components. In this kind of intervention, neurosurgical interventions in the brain, precision and accuracy are (naturally) among the most important aspects. However, the definition of these concepts might differ between surgeons and physicists as shown in [Dinka et al. 2005]. Nevertheless, all the subjects of this trial preferred to use the 2D representation for final planning. The data suggests that the uncertainty was associated with the transparency of the 3D prototype. (For a general discussion of transparency see [Dinka et al. 2005:2]. In particular, the haptic force interface did not allow the users to inspect the model underlying the implementation, and there was no certainty that the model reflected their clinical own reasoning. Moreover, some of the physicists were concerned about whether the system would actually deliver the dose described in the plan. (Note that the planning system, both in LGP and the test system, is separated from the intervention system, LGK.) The 2D version was experienced as being more accurate, and was necessary to make any final adjustments to the clinical plan.

The 3D environment was believed to be particularly useful when introducing new users to LGK. The 3D representation allows the user to get a conceptual understanding of the planning process and the following gamma knife intervention. In the current clinical implementation, there is the potential to have a plan presented in three dimensions, but it does not allow the user to perform actual planning in the 3D environment. However, the clinicians often use this 3D presentation to visualize the plan for patients and relatives (Dinka, Nyce, Timpka. The Importance of Professional Roles and Identity in Clinical Visualization System Design. Submitted 2005 to International Journal of Medical Informatics). This suggests that the clinicians believe that a 3D representation is easier to understand for viewers not used to the 2D slides used for today’s clinical planning. This also indicates why it would be beneficial to have this kind of representation available to
future planners. It does not, however, resolve how the transition between the 2- and 3D representations should be done. In fact, some of the clinicians reported conceptual problems when moving from the 2D to the 3D representation.

Reactions were less positive to adding haptic forces to the 3D environment. The force feedback interface as implemented was apparently experienced to interfere with a process that the clinicians felt that they understood and controlled. When using the prototype system, the addition of forces was experienced as introducing unnecessary cognitive load into a crucial phase of the planning process. However, user attitudes may have been less negative if the forces had been differently implemented. For instance, some users suggested that implementing forces so that users were repelled from risk areas would have been useful. An interesting aspect of the haptic force implementation was that the users appreciated that it could provide additional feedback to them when interacting in the 3D environment. For instance, the prototype system provided contextual support while using menus, scrollbars and pressing buttons.

9.4.2. Clinical impact

The quantitative data recorded from the simulated clinical use of the systems indicated that the clinical accuracy generated by the prototype systems was slightly lower than the impact from using the traditional 2D representation. The 50% isodose coverage was an average 95.5% (95% C.I.) in the 2D representation. For the 3D system without haptics, the average coverage was 85.2% (95% C.I. ) and for the haptic system 84.6 % (95% C.I. ). This of course can be an artifact of the user’s prior and intensive experience of 2D applications. These results suggest that adding the haptic force feature did not improve accuracy over the 3D representation in this setting.
9.4.3. A small-scale theory of clinical visualization practice

Measurement of the clinical outcome of using visualization technologies in radiosurgery, thus the effectiveness of these technologies, has been found to be difficult, because it is often hard to compare two treatment sessions to each other [Dinka et al. 2005:1]. This is mainly due to the fact that every patient is unique and the tumors are of different types. Previous research has also shown that the definition of effectiveness differs between user groups. For instance, from a medical physicist perspective, the definition of outcome would be close to dose precision. However, asking a neurosurgeon, the definition of outcome would relate to the long-term morbidity and mortality of patients. Nevertheless, despite methodological difficulties, there is still constant progress in radiosurgery with regard to improved overall survival rates and decreased post-surgical morbidity. Measurement of clinical impact is more straightforward, due to the fact that it can be derived directly from the DVHs. When we explored the clinical impact of using different generations of visualization technologies, our data suggested that the differences between 2D and 3D representations were quite small. Considering aspects such as the previous experience of users and the fact that this was a prototype system, it remains an open question whether the impact generated in clinical 3D environments in future design could become superior to those produced in current 2D environments.

Our data suggests that the 3D environment increased the clinicians’ feeling of being in control in the beginning of the planning process. One reason for this fact may be that the clinicians were able to inspect and interact with a representation of a brain that they do not have to reconstruct time after time. This not only seems to have reduced workload, it gave the user a greater feeling of control. In other words, the level of trustworthiness and realism was found to be sufficient to allow immersion into the virtual reality created by the 3D representation.
What this means is that the clinicians experienced a “useful” representation of both the brain and the target, even though they knew that it was only a computer-generated image. The level of immersion was, here, related to the availability of images that were used in a traditional clinical situation, i.e. the representations the user would have been trained on and would be available in almost any clinical situation. The interaction could hence be related to previous experience, and thereby would have been acceptable to end-users in order to support their desire to be in control (see [Dinka et al 2005:2] for discussion of control).

In the second step of planning radiosurgery, when fine adjustments are made, the increased control and precision that is needed is traditionally gained by removing information that is not necessary. Accordingly, the traditional 2D interface was also preferred in the present study because it only gives the user the information required for determining treatment. In the 3D representation, the information presented forces the user to plan and think in 3D and this increased the workload. This might be why users feel that the 2D representation is better suited for fine-tuning a plan, and the 3D is better suited for quick initial planning.

Users responded differently to haptic forces. The users’ main need for the visualization system was control, even if neurosurgeons or physicists require different kinds of control depending on the role they play in clinical work [Dinka et al. 2005]. The implementation of haptic forces in this test system was of a guiding kind. This means that the idea behind the forces was that they were to indicate to the user where to put the radiation shots, by increasing or decreasing resistance. This kind of guidance turned out to be something users neither wanted nor found to be useful. This of course was because this kind of haptic implementation conflicts with the user’s own need to control clinical interventions. If haptic forces are implemented, the use of these forces must be more in line with the user expectations and roles. Another aspect of haptic implementation, which is related to the previous one, is the aspect of added-value. To implement haptic force feedback as a
navigation support may have been a good idea when introducing the initial versions of the 2D system. However, today, when clinicians already are proficient planners, they are not able to recognize a significant added-value from force feedback in the planning. Compared to the 3D representation, where the added-value was recognizable, haptic implementation did not add any value for the users, and thereby this aspect of the system was not considered as beneficial.

The use of visualization technologies in radiosurgery can be better understood from a historical perspective. This small-scale theory shows that the use of 2- and 3D environments, including the haptic force feature, requires a coordinated development of control, clinical precision and effectiveness (Figure 16). The development of these aspects can be illustrated on a common time axis, where arcs representing each aspect have different slopes.

<table>
<thead>
<tr>
<th>Form of representation</th>
<th>1D-representation</th>
<th>2D-representation</th>
<th>3D-representation</th>
<th>3D-representation + haptic</th>
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</thead>
<tbody>
<tr>
<td>Function</td>
<td>Command line based planning</td>
<td>Integrated images (e.g. MRI or CAT)</td>
<td>3D-generated images from MRI or CAT</td>
<td>Haptic functionality in interaction</td>
</tr>
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<td>Beneficial</td>
<td>Ok</td>
<td>Few benefits</td>
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<tr>
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<td>Unclear</td>
<td>Unclear</td>
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<td>Effectiveness</td>
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<td>Beneficial</td>
<td>Few Benefits</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
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</tbody>
</table>

*Figure 16*
9.5. Discussion

The aim of this study was to investigate how neurosurgical practitioners use and experience interaction with 3D representations of the human brain and a GiD involving haptic force feedback. 2D interaction methods were used as baseline and the analysis was made with regard to both clinical impact and user satisfaction. It was not obvious how to implement haptic forces to fit the needs of a neurosurgeon or a physicist and this requires further investigation. However, the first implementation presented here provides suggestions regarding design requirements.

Previous research suggests that the need for 3D representations is highest when users are performing 3D tasks [Raskin, 2000]. However, there is also an important distinction between 2D interaction, for instance, in word-processing, and being forced to use 2D interaction when performing a 3D task, such as planning a surgical intervention where the object is 3D. The latter task forces the user to switch modes from the initial 3D context, to a 2D representation and 2D interaction, and then back to the 3D context to be able to understand the result. It remains an open question whether this is perceived by users as problematic. It may be that this increases the cognitive workload and switching between these different representations increases the risk of errors and confusion and, therefore, for a multitude of reasons should be minimized. However, this point requires further research.

The skepticism towards the haptic force implementation reported here might be traced to users’ clinical agendas. If implementing forces that are more inline with their professional role and the work at hand, then there is potential for a positive response to haptics. Comprehension and usefulness of the forces are likely to increase if they reflect the way the user sees his or her work and thereby user identity. According to related research on visualization and GammaKnife use (Dinka, Nyce, Timpka. The Importance of Professional Roles and Identity in Clinical
Visualization System Design. submitted), the function users desire differs depending on user identity. The main issue here is that experience and personal history define which functions are desirable and which improvements need to be prioritized.

GammaKnife users traditionally have a background as either neurosurgeons or medical physicists. The differences between these groups of users have been oriented towards control and clinical treatment success rate. Physicists have a tradition of control and quality assurance in the sense that aspects such as accuracy and precision mark and define successful treatment. Neurosurgeons, in contrast, do not emphasize accuracy and precision that highly. Neurosurgeons do not neglect these aspects, but they focus more on clinical success. The so called “objective” differences between these two approaches might not be that great, however when it comes to representations and the graphical interface, the shift in can be significant and has to be taken into account in design requirements.

So, what does this have to do with haptics and 3D visualization? The forces implemented were not perceived by users as the “right” ones and as such had no immediate perceived benefit for either user group. We believe that this is largely because their professional socialisation is built on 2D representations. The paradox here lies in that as we attempt to “simplify” their cognitive workload by delivering 3D representation and tactile feedback, we may actually make the interaction more complex. This, however, does not mean that haptic forces in this kind of application have to be abandoned. Rather, it means that forces must be adapted to user identities and the work they carry out.

In the implementation described here, the “nature” of the tumour is implemented into the way that the surface can be felt through the GID. This adds physical properties to the target. Even if not true to a “real world” sensation of the target, it is a recognizable physical behavior. Put differently, the idea that underlies this haptic design is the assumption that haptic “works” best for users when it captures and imitates “real world” events and phenomena, in this case the resistance...
to an object’s surface. The reasoning here is the “best” use of haptic force and 3D representation is that of mimesis or imitation of things in the real world. In brief, objects as presented in a haptic environment not only have to be recognizable, i.e. look as “real” as possible, but these objects also have to obey natural laws. Perhaps users require useful representations, not necessarily “real” ones.

In this case, it may not be necessary or even appropriate to have the haptic interaction “push” users in the direction of the target. Clinicians can already easily identify and focus on a target. To do so further is a great mark of the extent of their competence and ability to perform work they were trained to do. The implementation used diminished user control and “black-boxed” what for these users is self-evident and apparent.

Previous research has also shown that accuracy and precision are highly prioritized aspects of radiosurgical practice, especially for physicists. The issue we need to address is how to make this new technology (3D and haptic) complement existing ones by supporting specific clinical needs. For example, these technologies could be used to create a better understanding of the target in gamma knife therapy. In the traditional 2D system, the isodose lines are representations of place and strength (the location is visible in relation to the image, and the strength is represented by the distance from the shot). A haptic system would enable the user to feel an immediate sense (validation) of the consequences of a particular treatment plan. For example, the planner could “hold” the target in their hands and the effect of the radiation doses placed on the target could be indicated by a sense of structure or density of the target. This would enable clinical staff to assess risk to both targeted organs and adjacent structures. This, of course, is an important part of what needs to be considered in any treatment plan, but there are few tools currently available to end-users to help them with this task. In short, instead of replicating the existing haptic interaction paradigm, one in which the user is given the experience of control in reference to strictly “real” world vectors, the
new implementation suggested here would add control in areas of interest to the user.

If we are going to implement haptic forces we have to better understand the users’ professional roles, their concept of work and how work competence and context determine clinical action. We need to implement a haptic design agenda that reflects central principles and categories of the work the users perform. For example, a central design question for using haptics in LGP would be how the different understandings neurosurgeons and physicists have of precision and accuracy regarding clinical targets could be transferred to haptics and accompanying 3D interfaces.

Another question for future research is to examine how different representations form an acceptance of accuracy and precision. Since this study had a small number of respondents, and due to the nature of the setup, it was not possible to see if the differences in DVH measurements depended on the representations or if the differences were related to experience. However, in a future study, we should examine how users score their results depending on representation. In other words; if the users tend to accept a lower percent of coverage in the 3D representation because of the representation itself, or if this acceptance can be traced to experience and training.

One aspect of Patient Satisfaction is the way in which the representation is used as an explanatory tool when explaining the treatment and the effects. Today, the 3D representation built in the LGP is used mainly for presenting this information to patients. Some of the participants in this study saw 3D representations as an easier way of describing the process to their patients. The easy-to-understand system of today would, from the user perspective, be a guaranty that it would also be easy to understand for novices such as patients.

The three different environments have, in this study, proven to have different qualities and drawbacks. User views of the tested system were generally positive. However, the test system was not seen as a
replacement of the existing LGP, neither with 3D interaction nor haptics. However, as a complement the technology could, if further developed, have the potential to be a tool suited for planning and patient education. Obtaining a 3D view on a 2D screen, as in LGP today, the actual interaction entails an extra workload for the user using. This occurs by forcing the user to scroll between the different MRI slides in order to inspect the whole target. It remains an open question whether the user, when creating a 3D representation concept on the fly, incurs an extra workload.

9.6. Conclusions

This study showed how important it is to for haptic design to take into account issues generally covered under the terms “use” or “context.” To ensure end-user acceptance, the users’ professional roles and their concept of work have to be considered when designing 3D representation and haptic interaction. The implementation included several features appreciated by users, for instance 3D representation and the real-time updated isodose. However, the haptic forces as implemented were not equally as appreciated. This raises a series of questions regarding how force and object are represented in haptic design. Perhaps we should design in the direction of usefulness (as our end-users understand the term) and not in the direction of what we term as “natural.” By gaining better knowledge of users and their work, it may be possible for haptic designs to move from the laboratory into the real world.

9.7. References


computing systems, Ft. Lauderdale, Florida, USA, 5-10 April, pp. 193-200.


Hidden Tracks

As a final notice, and maybe not that official, I need to include the soundtrack for this work. These songs have been the most played, and my favorites, in my iPod during these years. Enjoy!

First the already known...

<table>
<thead>
<tr>
<th>Track</th>
<th>Artist</th>
<th>Album</th>
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<tbody>
<tr>
<td>Shoreline</td>
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<td>Cruel Town</td>
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<td>Covenant</td>
<td>Sampler: Remix and Rarities</td>
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<td>Paris and Rome</td>
<td>Cranes</td>
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<tr>
<td>Ende Neu</td>
<td>Einstürzende Neubauten</td>
<td>Ende Neu</td>
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<tr>
<td>Single (Photek remix)</td>
<td>Everything but the Girl</td>
<td>EBTG vs. Drumm’n bass</td>
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<td>Interpol</td>
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<td>MIA</td>
<td>M.I.A</td>
<td>Arular</td>
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<td>Massive Attack</td>
<td>Singles 90-98 (Disc 8)</td>
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<td>New Order</td>
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<td>Comfortably Numb (ATOCEnd)</td>
<td>Scissor Sisters</td>
<td>Remixed!</td>
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<td>Body and Soul</td>
<td>The Sisters Of Mercy</td>
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<td>Shout (Original mix)</td>
<td>Sophie Rimheden/Håkan Lidbo</td>
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<td>Less Than Perfect</td>
<td>Statemachine</td>
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<td>Stina Nordenstam</td>
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<td>VNV Nation</td>
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The Extended version

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<td>The Beauty</td>
<td>Abide</td>
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<td>Can I Kick it?</td>
<td>A Tribe Called Quest</td>
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<td>Circles</td>
<td>Adam F</td>
<td>Colours</td>
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<tr>
<td>Eclipse</td>
<td>Apotygma Berzerk</td>
<td>Welcome to Earh Promo</td>
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Shot You Down                          Audio Bullys & Nancy Sinatra  Shot You Down
Den Lilla Planeten                    Bob Hund                          Den Lilla Planeten
Bug Powder Dust                      Bomb The Bass                    Beat Dis
Janie Jones                           The Clash                        Clash
Enjoy The Silence                     Depeche Mode                    Violator
Blood On The Motorway                 DJ Shadow                        The Private Press
Love Under Will                      Fields Of The Nephelim           Earth Inferno
Flow My Ashes                         Freddie Wadling                  Kobra
Lifeline                              Front Line Assembly               Tactical Neural Implant
Happy When It Rains                   The Jesus And Mary Chain        Darklands
Her Way Of Praying                    The Jesus And Mary Chain        Automatic
Hurt                                  Johnny Cash                      American IV: The Man Comes Around
Suicide Is Painless                  Johnny Mandel                    M*A*S*H
Transmission                          Joy Division                     Substance
Om Du Var Här (Unloaded remix)       Kent                              Om du var här
Die Mensch-Maschine                  Kraftwerk                        Die Mensch-Maschine
Eurochild                             Massive Attack                   Protection
State Of The Nation                  New Order                        Brotherhood
Physical (You’re So)                  Nine Inch Nails                  Broken
Sour Times                            Portishead                       Roseland NYC (Live)
Body and Soul                         The Sisters Of Mercy             A Slight case of Overbombing
Negative Feedback                    Statemachine                     Breakdown
Blinded By The Lights                 The Streets                      A Grand Don’t Come For Free
Dear God                              Tricky                           Vulnerable
Nobody’s Diary (12” Mix)             Yazoo                            The 12 inch Mixes

And of course

Somebody                             Depeche Mode                   Some Great Reward


No 297  **Mariam Kamkar:** Interprocedural Dynamic Slicing with Applications to Debugging and Testing, 1993, ISBN 91-7871-065-0.


No 439  **Cecilia Sjöberg:** Activities, Voices and Arenas: Participatory Design in Practice, 1996, ISBN 91-7871-728-0.


Linköping Studies in Information Science


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