DESIGNING WORKPLACES FOR CONTROL ROOMS: A STUDY USING FOCUS GROUPS AND STAKEHOLDER INTERVIEWS

Elisabeth Weissenböck * Margit Pohl
Vienna University of Technology *
Argentinierstraße 8, A-1040 Vienna, Austria *

Peter Judmaier Andrea Viertelmayr Gernot Rottermanner *
St. Pölten University of Applied Sciences *
Mathias Corvinus-Straße 15, A-3100 St. Pölten, Austria *

ABSTRACT
Control rooms for supervising traffic or emergency situations are increasingly introduced in companies and other governmental organisations. Employees of safety-critical workplaces have to deal with a large amount of problems every day: Quick decision-making, coping with an overload of information and stress are the most important. Designing appropriate workplaces for employees in such organisations is essential. The following paper provides the results of focus groups and stakeholder interviews which were conducted in two companies with control rooms regarding these issues.

KEYWORDS
Interface design, large screens, gender, evaluation

1. INTRODUCTION
Supervising complex processes in industry and governmental organisations is an increasingly important research area. Power plants, traffic control, and the organisation of emergency and rescue operations require a close control. Computer technology is typically used to achieve this. It is clear that the supervision of such processes is a challenging activity and has to be supported appropriately. In this context the design of the workplaces of control room operators plays a crucial role so that the attention of these employees is maximised and stress minimised. A specific challenge in this context is, for example, the fact that control room operators work with large screens. Therefore, information has to be presented in a way so that the necessary data can be perceived immediately. In addition, gender issues have to be taken into account. It is an open question whether the appropriate design of control room workplaces can help to make them more attractive for women.

The investigation presented in this paper addresses these issues. On the one hand, we studied, more generally, how the physical design of the workplace influences the work of the control room operators. In this context, we are especially interested in the design of the interfaces of the large screens which are used in control rooms. In addition, we also addressed more general issues of workplace organisation (choice of chairs, personalisation of workplaces,...). We did not specifically address the issue of work organisation, although we would like to point out that these issues are related to each other.

We also addressed, more specifically, the issue whether physical workplace design might be one factor which is responsible for the lack of women in control rooms. There is some indication in the literature that under some circumstances women might prefer a different interface design than men.

The research described in this paper was conducted in the context of a research project. We were lucky to be able to cooperate with two organisations which permitted us access to control room operators who were
willing to participate in this study. It is well known that such access is difficult to get, therefore, our results are especially valuable.

2. DESCRIPTION OF THE PROJECT

The aim of the project GenSiSys was to analyse the work in control rooms and also to develop a set of recommendations how to evaluate gender and diversity aspects in safety-critical workplaces regarding needs and requirements of employees in ergonomics and human computer interaction.

Safety-critical workplaces are systems where decisions, actions or mistakes by operators and controllers directly affect human lives. Working at a safety-critical workplace means to make quick decisions, coping with an overload of information and stress.

We were lucky to find two very open and cooperative partners which provided the project team with comprehensive support. One of the partners was the 144 emergency call control centre of Lower Austria (144 Notruf Niederösterreich) in St. Pölten. The other partner was the operations management centre of the Austrian Federal Railways (ÖBB).

In the context of the project, we conducted an extensive review of the literature. Based on this, we developed 19 issues which have to be taken into account when investigating the physical work environment of control room operators. We also identified a set of research methods from Social Sciences and Human-Computer Interaction which are appropriate for the investigation of these issues. In the following, we present one of the studies we conducted during the project which is based on a subset of the issues mentioned above and two methods – focus groups and stakeholder interviews.

3. RELATED WORK

There are several features of systems deployed in control rooms which influence the quality of the work of the operators.

Size of the display: Large displays raise challenging new questions concerning interface design. One of the most important problems which may arise in this context is the fact that humans only perceive a small portion of the screen with high acuity (change blindness, inattentional blindness). Due to the size of the screen it may happen that relevant parts of the information is not perceived by the user. Mancero et al (2007) discuss empirical results concerning these issues. They argue that change blindness can have negative effects on the efficiency of users of large displays. They point out that there are several aspects which have to be taken into account. Slow changes, for example, are difficult to perceive. Changes which happen outside the focus of attention of the users are often overlooked. Saliency of important information should be aimed at. In addition, they also point out that meaning and relevance play an important role.

Complexity of the System: Providing the user with the right information and visualisation at the right time is necessary for prompt decision making. It is therefore important to support users to deal with a complex system. A complex system provides a large amount of information from heterogeneous sources and a great variability of interaction possibilities. On average, simplicity of a system is more important to women than men (Stadler, 2006). A high complexity of the system often leads to stress.

Decision making: Men and women “... both carefully process information, retrieve the relevant decision-related data from their memories, categorize the data if they are very diverse, think logically about the alternatives, predict results, evaluate the consequences, solve the problems posed by the situation, and monitor all the decision stages” (Sanz de Acedo Lizárraga et al. 2007, p. 387). Making fast decisions and analysing data seem to be more important for men, whereas women, on average, seem to take more time and are more worried about the consequence of their decisions (it doesn’t matter if the decision has an influence on themselves or others) (Reiter, 2013).

Design of the displays: In control rooms, the usage of large displays has increased (Pohl, 2013). It is very challenging to find relevant information on large displays. Large displays with a wide field of view can support both women and men, although women benefit more (Czerwinski et al. 2002). Icons are a way to provide users with important information: it is necessary to use simple figures which are easy to recognize for the user, and they should be used when the user’s interaction is required (Yu & He, 2010). Not only in
control rooms, also in emergency medical situations icons have to be promptly recognized (Salman et al. 2012): to guarantee that, it is a viable option to design and implement icons together with the users. This cooperation of user and designer is necessary to achieve an reliable recognition of an icon (Gatsou et al. 2011).

Personalisation: According to (Wells, 2000) personalisation of workplaces can have a positive impact on job satisfaction and well-being. Ease of use and usefulness of software can be positively influenced by personalisation (Henriksen & Pedersen, 2009).

Stress: Stress as a factor influencing the work of operators in control rooms has been discussed extensively, e.g. in the context of nuclear power plants. Desaulniers (1997) provides a general discussion of stress in control rooms. He discusses the consequences of stress (narrowing of attention, reduced working memory capacity, …) and possibilities to reduce the number of stressful situations in control rooms (training, improved procedure design, …). Farkas et al (2011) point out the importance of reducing the operator’s mental load to ensure that he or she can react efficiently in emergency situations. Mukherjee et al (2010) discuss the design of control rooms, especially the trend to reduce the amount of information which is presented to the operator. In this context, some of the tasks which were carried out manually by operators were taken over by computers, especially repetitive and monotonous tasks. This leads to a reduction in panel complexity. In this way, stress can be reduced.

4. DESCRIPTION OF THE INVESTIGATION

The goal of the investigation described in this paper is to identify how workplaces for employees in control rooms can be improved to reduce stress and increase the efficiency of their work. The work described in this paper focuses on this issue and does not address the problem of work organisation, but both issues are, of course, related to each other.

Our research goal was to identify which factors concerning the workplace influence the quality of the work of operators in control rooms. We were especially interested how the design of the system affected the decision making process. We assumed that stress is an important factor in this context. The research questions were developed as a result of an extensive literature study by experts from different fields (usability experts, ergonomics experts, cognitive psychologists, gender studies experts).

There are several possibilities how the quality of the design of the workplace could be investigated. We think that the employees’ views and attitudes plays an important role in this context, therefore we chose focus groups and stakeholder interviews as research methodologies. We conducted three focus groups with control room operators of two organisations. We conducted focus groups with the operators because we were interested in the discussion among these employees and the shared sensemaking processes. In addition, we conducted interviews with stakeholders from management to clarify their view of the issues related to the work processes in control rooms. We decided to conduct interviews with the managers because we also wanted to discuss more sensitive issues with them which could not be discussed in a group.

4.1 Focus Groups

Focus groups are group discussions. They are a form of qualitative research (Kuniavsky 2003). A facilitator using guidelines asks participants questions they can and should discuss. Possible ambiguities can be removed through repeated discussion of an issue. One main advantage of focus groups is that unclear or controversial issues can be clarified in the discussion. Sometimes, problems occur when single participants in focus groups dominate the discussion. Facilitators can mitigate this phenomenon by encouraging all participants to share their thoughts with the others.

While using experiments in safety-critical systems, special conditions have to be considered: operators cannot leave their workplace for long. In many situations, tests can only be conducted after the employee’s shift, which often lasts 12 hours, or during a break. Therefore we were glad to get the chance that a considerable number of employees took time to participate in the focus groups. It has been a great advantage for our work to get to know employees and to talk about their problems, issues and needs in a real setting.

Based on the literature, these were the questions we asked:

**Ergonomics:** Are you satisfied with your chair?
Complexity of the systems: On the one hand there are systems which provide many features and are therefore difficult to learn and master, on the other hand there are systems which have fewer features and are therefore less error-prone, easy to learn but do not provide many features. How would you describe your system?

Decision making: How do you make decisions in situations where you have to act as quickly as possible?

Displays: How do you get along with many/big displays? Do you ever have the feeling of overlooking something important? Are there any ambiguities in the software? (Icons, shortcuts,...) Do they lead to delays? Are mistakes made because of unclear icons? Are there any parts of the software where graphics should replace text or vice versa? If so, why?

Personalisation of software: Which parts of the software can be personalized? Do you use it? What do you use personalisation for? Is there a need for more? If so, why and where?

Stress: How would you describe your stress level at work? Which actions or times of day are most stressful? Do parts of the software stress you? How do you cope with stress, do you take stress home? If you think of a typical work day, when are the most stressful situations?

4.1.1 Focus Group NNÖ (Emergency control centre)

At “Notruf NÖ” two focus groups with a total of eight participants were conducted; four male and four female. Complexity of the used system, decision making, orientation/coping with many screens and stress seem to be the most interesting themes.

Employees are in general satisfied with the software because it is continually developed further and their feedback is taken into account. Nevertheless, there is some controversy in the group: Long-term employees have grown with the software. In contrast to that, newer employees have to get used to the system, the features and the processes fairly quickly. The common opinion concerning the complexity of the system is that it is directly linked to the main task. There are, basically, two groups of employees – call takers and dispatchers. Call takers receive emergency calls and decide which action has to be taken; dispatchers organise all activities (e.g. ambulances which are sent to a road accident). Call takers do not need as many functions as the dispatchers because they do not need all of them for their work. Most of the dispatchers are highly experienced females, whereas the call takers are younger males.

Decision making is a very important part of the participant’s job; they think that the system provides the right amount of support. Participants, who have worked for a longer period of time for Notruf think they have no problem with choosing the right protocol when it comes to an emergency call (every emergency has its own protocol, so they can ask the caller the right questions and provide help), whereas less experienced employees are not always that sure. If there is a difficult decision to master, they are never left entirely on their own: asking a colleague or the shift supervisor for help is always an option.

Call takers use two displays whereas dispatchers have got four displays which provide them with different information: the first is for transportation, the second for showing ambulances, the third for the map and the fourth is for additional information. The prevailing opinion is that, due to the fixed places of the displays, it is clear which display provides which information.

Stress seems to be the most important issue of the two focus groups, due to the diversity of stress factors: medical service which starts at 7 pm, the wish for more personnel and issues regarding the building (e.g. heat) are mentioned as stress factors. In Lower Austria, it is possible to get advice from a physician after 7 p.m. via the Notruf, either on the telephone or, in emergency cases, the physician will visit the patient at home. This leads to an increased workload for the call takers after 7 p.m. and acts as an additional stress factor.

Four participants mentioned that the building, a low-energy house, is not ideal: sometimes it is too warm; high levels of noise are also a problem. The participants did not just talk about stress factors; they also were trying to find solutions during the focus group: a resting place, power napping and separated rooms were suggestions which came up in the discussion.
4.1.2 Focus Group ÖBB (Austrian Federal Railway)

At the ÖBB one focus group with six participants was conducted; three of them male and three female. Four topics were addressed: complexity of the used system, decision making, icons and stress.

Participants use many different systems; the prevailing opinion is that systems which are used often are well known. Systems are kept simple, but most systems are quite comprehensive. Employees are rather satisfied with the operation of the systems and are not overwhelmed by the features these systems provide. One participant observed that the telephone provides too many features; most of them are not used often which can lead to a tedious search.

Personalising the screens is very important for the employees to make it easier for them to find all information they need in emergency situations. One participant mentioned that he/she moved unnecessary information to the top right screen because he/she knows that this is his/her “blind spot”. The disadvantage of personalisation is that employees cannot use another person’s workplace easily, as they need to log out and then in with their own profile.

Icons which are needed in safety-critical situations are well known; an icon catalog provides help if needed. Disturbances are shown in yellow unless they are acknowledged. A blue signal indicates a track disturbance and a textbox shows which trains are affected and which measures should be taken. A search function is a proposal of one of the participants and is approved by the others.

Stress can go from zero to hundred very quickly, it depends on the disturbance. Malfunction of the switch, construction works and conservation work are mentioned as typical disturbances. Participants think that an update of the database is stressful, because they cannot access the information system during that process. Most disturbances are handled on the phone, so a failure of the telephone system would also lead to a stressful situation.

4.1.3 Discussion

In our study the number of participants is too small to make a general statement about gender. Nevertheless, we think that we can clarify some methodological issues for research in this environment and, in addition, indicate some areas where further research is necessary. We identified four areas which are relevant for the design of workplaces: complexity of the system, decision making, navigation/personalisation, and stress.

In general, employees in the control rooms we investigated were quite happy with the systems they used. This indicates that the problem of designing large displays for control rooms is not as challenging as is discussed in the literature (Mancero et al 2007). This is to a certain degree dependent on the experience they already have. A few minor usability issues were mentioned. Personalisation is used to counteract possible negative effects of these large displays. This seems to be a possible solution for some of the problems of large displays. Decision making processes are fairly well supported by the systems. The employees also mentioned that cooperation between employees is very important for reliable decision making. Stress is mentioned as the most important problem by employees from both organizations, although it is more relevant for Notruf than for ÖBB. The participants of the focus groups not only discussed stress but also made interesting suggestions how this could be overcome.

Gender does not seem to be a factor which is highly relevant for workplace design in this context. We could not identify indications that there are different approaches based on gender as has been suggested in the literature. We would also like to point out that Notruf is a specific kind of organization because a considerable amount of operators, especially the dispatchers who have more responsibilities than the call takers, are mostly women. These women feel very comfortable with a fairly complex system. This also indicates that the situation in control rooms is not as stereotyped as can be expected from the literature.

4.2 Stakeholder Interviews

Stakeholder interviews offer, in combination with other evaluation methods, in particular with a focus group, a high gain in knowledge (Bortz & Döring 2006, Goodwin 2009). The analysis can be done in areas such as work environment, workplace design, software interaction, stress perception and problem awareness. The two perspectives (stakeholder, focus group) decrease the risk of a one-sided analysis. Furthermore, stakeholder interviews are characterized by low cost in equipment, as only sound recording (e.g. with a voice
A recorder or mobile phone is necessary. The interviews can be conducted by a single person who should have experience in negotiation (clear language and skills in conversation techniques). Unlike other methods - contextual inquiry, for example - this method is not tied to the actual workplace, but rather can take place wherever the requirements for a confidential, undisturbed conversation are provided.

While there are quite some advantages, there are also a few disadvantages. For one, the organisation of appointments for the stakeholder interviews and working on an interview outline can be quite time-consuming. Evaluating the recorded interviews is also rather laborious, as they ought to be transcribed or at least summarized. The aggregation of the results and the knowledge analysis is yet another time consuming task.

4.2.1 Stakeholder Interview NNÖ (Emergency control centre)

The three main topics of the three stakeholder interviews conducted at “Notruf NÖ” in Lower Austria were workplace, stress level and work atmosphere.

One of the challenges stated in these interviews was to acquire appropriate chairs to ensure that employees can sit comfortably for as long as possible. At the control rooms employees can choose between three different types of chairs by various manufacturers. Though, these chairs do not always comply with the various requirements of the employees. To reduce the quantity of information, the work environment itself is characterized by a low amount of monitors and the possibility to personalise the software environment to one’s specific needs. Furthermore, usage of the colour red in the user interface was reduced, as important elements did no longer stand out enough.

The main focus concerning the topic stress level was the work load (processing emergency calls and dispatching vehicles), especially when dealing with extensive emergencies. So, the primary goal is to improve the standardized procedure (Advanced Medical Priority Dispatch Systems – AMPDS), that the semi-automated decision process can help reducing the stress level for employees. Furthermore, measures like basic & advanced training and pre- and post-care are offered, and simulated situations are being run through to increase experience and help in turning tasks into a routine more quickly.

The interviewed stakeholders put emphasis on the fact that the equal gender ratio makes for great teamwork in the individual teams. The balance is due to the fact that the percentage of women and men working as paramedics is even, and these are the people mainly applying for a job in an emergency control room.

4.2.2 Stakeholder Interview ÖBB (Austrian Federal Railway)

In the interviews, carried out with four stakeholders of the Austrian Federal Railways, four topics seem to be relevant. These topics are ergonomic issues concerning the work places, the monitors themselves at the workplace, and coping with stress and the work atmosphere.

Almost all of the employees use the possibility to set up an individual workplace for their requirements during their shift. This encompasses the desk height which can be adapted to sitting or standing posture or the content of the monitor of the 10 monitors, and the colour of the track lines, which show the location of the trains in real time. The profile of an employee is active when they log into their account at their workplace.

As mentioned every employee has 10 monitors to interact with, although some of them only use around five of them, as the work profile of the dispatcher varies and includes diverse needs. The occupational health care and the transport inspection limited the monitors to 10 in regard to the limit of the coverage possibility of a human being.

The employee’s work in an open plan office and the background noises, which naturally come with this form of work organisation, were mentioned by some interviewed stakeholders, as kind of disturbing. In general, trainings are seen as support for the employees as well as the cooperation among each other, especially from seniors to younger colleagues.

4.2.3 Discussion

Interview partners in the stakeholder interviews talked mostly about ergonomic issues and stress. They pointed out that workplaces can be arranged individually to make it easier for the employees to work in front
of computer screen for several hours and to enable them to concentrate on their work. Operators can choose between different types of chairs, change the height of their tables, personalise the contents of their screens etc. Screens and interfaces are designed in a way to support human perception (e.g. reduction of the number of screens, avoidance of the colour red). Both organisations adopt measures to reduce stress (improved protocols, training). Stakeholders from Notruf especially pointed out the gender balance in their organisation in control rooms.

5. CONCLUSION

The goal of the study presented in this paper is the analysis of workplaces in control rooms. The emphasis was on the design of the computer interfaces and the physical design of the workplaces. We conducted focus groups with employees and interviews with the managers. This provides us with the possibility to look at the challenges of the design of control rooms from different perspectives. The employees tended to discuss these issues from the point of view of their personal experience. In general, they were satisfied with the interface design of the software systems they used and had no major problems with the system. Working with large screens does not pose specific problems. Based on existing literature, we had expected that working with large screens would pose more serious problems. The interview partners mentioned several possibilities how to cope with the large amount of information provided by large screens (especially personalisation and appropriate screen design). The major problem mentioned in both organisations was stress, especially in Notruf. The managers discussed these issues from a leadership perspective and mentioned various measurements taken to alleviate the problem of stress (training, collaboration among employees, improvement of protocols).

It is well-known that the employees in most control rooms are predominantly male. Therefore, we also addressed the question whether aspects of the interface design or the physical organisation of the workplace favour male employees. In our investigation, we could not find such aspects. We would like to point out, however, that one of the organisations we cooperated with had an even distribution of women and men as control room employees. On the one hand, this might have influenced our results. On the other hand, it indicates that the work of operators does not per se have a “male” character.

Conducting studies in control rooms poses specific challenges. It is one of the advantages of this investigation that, thanks to the cooperation with the two organisations, we had access to a considerable number of control room employees. Due to their workload it is, in general, not possible to conduct investigations with this type of employees during working hours. Therefore, focus groups and interviews are appropriate methods for this kind of investigation. We found, that we were able to gain interesting insights into their work processes and the specific problems they have.

One limitation of this study is the fact that we were only able to conduct focus groups and stakeholder interviews with a limited number of persons. This makes it difficult to generalise these results. Nevertheless, we would like to point out that it is extremely difficult to find interview partners in this area. Therefore, this study is still a relevant contribution to the field. Another limitation is that we did not investigate work organisation and relationship among employees. It can be assumed that gender issues are more easily visible in this area. Nevertheless, we did not want to mix up these two issues (design of workplaces and work organisation). There is less research concerning gender issues in the design of computer interfaces and more general in the layout of the workplace, therefore we wanted to investigate this issue in more detail.

Further research concerning these topics is necessary. One possibility in this context would be to conduct a study with more participants from other organisations. In addition, it would be valuable to include additional questions, as for example, organisational issues and also additional aspects from the area of ergonomics. It would also be interesting to study the workflow of the employees in more detail to get more objective data on the interaction processes of the participants with the IT systems.

ACKNOWLEDGEMENT

The project GenSiSys was funded by the Austrian Ministry for Transport, Innovation & Technology, FEMtech 2nd call.
REFERENCES


Reiter, K.R., 2013. *Gender Differences in Decision Making When Faced with Multiple Options*. College of Saint Benedict and Saint John’s University.


