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Evaluation of software ergonomic user requirements of laser engraving systems by using focus group discussions

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MASTERS'S THESIS

submitted in partial fulfillment of the requirements for the degree of

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Abstract

Companies aim for a high usability of their products, as a higher usability increases profit, reduces costs, retains existing users and attracts new users. To reach this aim, it is necessary to include the needs and requirements of (already existing and prospective) end-users in the design process, this approach is also known as user-centered-design. This approach ensures that all users can use the system equally well and is therefore the central issue of this master thesis, which was be accomplished in the context of the project GE:MMaS[1] at the department of Labour Science and Organization at the Institute of Management Science of the Vienna University of Technology.

In this master thesis, the user requirements of computer-controlled laser engraving systems were evaluated. The data for this survey were collected in focus group discussions with users of Trotec Lasers systems. Altogether three group discussions took place, each with a different kind of user groups – female operators, male operators and supervisors. The aim of this analysis is to determine differences between the different user groups. To raise the grade of objectivity of the analysis, two investigators evaluated the collected data. The content of the focus group discussions were recorded by dictaphones and cameras and transcribed. This transcription provided the basis for a content analysis, where the data was evaluated systematically. The data was unitized into units of sense and allocated into a category system, which was developed theory-driven as well as according to the material.

[1] Ge:MMaS (”Genderspezifische Anforderungen an die Entwicklung neuer Maschinen unter Berücksichtigung der Mensch-Maschine Schnittstelle”, German for ”Gender specific requirements for the development of new machines with consideration of the human-machine interface” is partly funded by the Austrian Research Promotion Agency FFG under grant No. 826182).

Kurzfassung

Das Streben nach einer hohen Gebrauchstauglichkeit (engl. Usability) ihrer Produkte ist für Unternehmen immer wichtiger geworden, da eine hohe Gebrauchstauglichkeit höhere Profite, geringere Kosten, die Bindung bisheriger Kunden und die Gewinnung neuer Kunden mit sich zieht. Um dieses Ziel zu erreichen, ist es wichtig, die Bedürfnisse und Anforderungen vorhandener und zukünftiger Endnutzer in den Designprozess einfließen zu lassen. Dieser Ansatz der Designentwicklung wird nutzerorientierte Gestaltung (engl. User Center Design) genannt. Dieser Designansatz soll sicherstellen, dass alle Nutzer das Produkt im selben Maße gleich gut nutzen können und ist daher das zentrale Thema dieser Diplomarbeit, welche im Rahmen des Projekts GE:MMaS[2] an der Abteilung für Arbeitswissenschaft und Organisation des Instituts für Managementwissenschaften der Technischen Universität Wien angefasst wurde. Inhalt dieser Diplomarbeit ist die Evaluierung von Nutzeranforderungen an computergesteuerten Lasergravursystemen. Die Daten für diese Untersuchung wurden in Fokusgruppendiskussionen mit Nutzern von Trotec Lasersystemen gesammelt. Insgesamt wurden drei Gruppendiskussionen abgehalten, jede mit einer anderen Nutzergruppe - weibliche Arbeiter, männliche Arbeiter und Vorgesetze. Das Ziel der Analyse ist die Determinierung von Unterschieden in den Bedürfnissen der einzelnen Nutzergruppen. Um den Grad der Objektivität der Auswertung zu erhöhen werteten zwei Investigatoren die gesammelten Daten aus. Der Inhalt der Fokusgruppendiskussionen wurde mit Diktiergeräten und Kameras aufgenommen und transkribiert. Diese Transkription war die Grundlage für eine Inhaltsanalyse. Dabei wurden die Daten systematisch ausgewertet. Der Inhalt wurde in Sinneinheiten unterteilt, welche wiederum in ein Kategoriensystem eingeordnet wurden. Das Kategoriensystem wurde dabei aus theoretischen Grundlagen entwickelt sowie mit Bezug auf das Material erweitert.

[2] Ge:MMaS („Genderspezifische Anforderungen an die Entwicklung neuer Maschinen unter Berücksichtigung der Mensch-Maschine Schnittstelle“, mitfinanziert von der Österreichischen Forschungsförderungsgesellschaft FFG unter der Projektnummer 826182).

Contents

1. Introduction

The interface between human and machine (HMI - “Human-Machine-Interface”) is an important issue for the approval and applicability of machines and software. Therefore, companies aim for a high usability of their products, because a high usability increases profit, reduces costs, retains existing users and attracts new users. The challenge is the complexity of today’s systems, because of that fact the complexity of user interfaces increased as well. To maximise the usability, it is necessary to include the needs and requirements of (already existing and prospective) end-users in the design process, what is also known as user-centered-design. This approach ensures that all users can use the system equally well. One of the many factors that influence the requirements is the user’s gender.

This master thesis, which will be accomplished in the context of the project GE:MMaS (”Genderspezifische Anforderungen an die Entwicklung neuer Maschinen unter Berücksichtigung der Mensch-Maschine Schnittstelle”, German for ”Gender specific requirements for the development of new machines with consideration of the humanmachine interface”) at the department of Labour Science and Organization at the Institute of Management Science of the Vienna University of Technology. In this master thesis, the user requirements of computer-controlled laser engraving systems will be evaluated. The data for this survey were collected in focus group discussions with users of Trotec Lasers systems. As Trotec is world leader in this industry, a relatively high amount of participants could be gathered for the group discussions. By now no usability surveys have been accomplished by Trotec, through a variety of problems in using their laser engraving systems have been reported by the operators. Altogether three group discussions took place, each with a different kind of user groups – female operators, male operators and supervisors. The evaluation of the focus group is intended to provide information about the requirements of the different user groups when operating on the laser engraving systems and what differences between the user groups are existing.

1.1. Ge:MMaS

The consideration of different genders in the development design of technical products in the ergonomic practice rarely carried out until now. In course of Ge:MMaS, this aspects are in focus. This should be get over by detecting designs for new machines which integrate the needs of people working with them, adjusted by their gender diversity.

Ge:MMaS is a project of the department of Labour Science and Organization at the Institute of Management Science of the Vienna University of Technology in cooperation with the Linz Center of Mechatronics GmbH, the Department of Women's Studies and Gender Studies, the Institute of Mechatronic Design and Production and the Institute of Technical Mechanics of the Johannes Kepler University Linz and is partly founded by partly funded by the Austrian Research Promotion Agency FFG[3] and investigates the requirements of user of Trotec laser engraving machines. Among the variety of machines these technical systems were selected for the survey because under these machine operators significantly less segregation than average in the secondary sector is common prevails.

The results of these studies will be summarized in a gender-specific requirements and will be used as guidelines new gender-machine developments.

1.2. Trotec

Trotec, the industrial project partner in Ge:MMaS, was founded 1997 out of a research area of Trodat, the world's leading manufacturer of self-inking rubber stamps. In the following years, Trotec developed and improved their laser system Speedy, a CO_2 laser plotter. Based on the success of Speedy, Trotec established additional branches worldwide and extended their product range with new technologies, such as fiber lasers and exhaust systems.

Today, Trotec is internationally recognized as the leading manufacturer of computer-controlled laser machines for laser engraving, laser cutting and laser marking, with approximately 200 employees work at 13 branches worldwide and customers in more than 90 countries. Their main product lines are Rayjet and Speedy, which defined new standards in the use of lasers. The main applications are rubber stamps, signs and displays, awards and

[3] grant No. 826182

trophies as well as a wide range of promotional items, like individual business card boxes shown in Figure 1. Common materials cut or engraved with the laser are acrylic, wood, paper, metal, plastics, glass, leather or stone.

FIGURE 1 - INDIVIDUAL BUSINESS CARD BOX, LASER ENGRAVED[4]

The Speedy product range provides lasers in different sizes with different laser types (CO_2, fiber, etc.). As example, Figure 3 shows the Speedy 500, one of the large size laser systems. In Ge:MMaS and therefore in this thesis, the human-machine interface is in focus. Thereby, the general construction, the control panel of the laser engraving system, shown in Figure 2, as well as the engaged software, will be examined.

[4] © Trotec, 2015

FIGURE 2 - TROTEC CONTROL PANEL[5]

FIGURE 3 - TROTEC SPEEDY 500 [6]

[5] © Trotec, 2013
[6] © Troctec, 2013

1.3. Structure of this thesis

This work is structured into ten chapters. The first chapter gives an introduction and an overview about the project behind this work, as well as the projects environment. Chapter two considers with the main theoretical background of this work, ergonomics, including software ergonomics. Chapter three descripts the applied data collection approach, Focus Groups, and chapter four the applied evaluation approach. Chapter five goes from the theoretical in the empirical part and shows the results of the investigations, as well as a discussion about them.

Finally, chapter six to ten contains the conclusion, bibliography, list of figures and tables and the appendix.

2. Ergonomics

Ergonomics is best described by a quote of the scientist Wojciech Jastrzebowski, who states ergonomics as *"a scientific approach, so that we reap the best fruits on the slightest exertion and with the highest satisfaction for our own and the general welfare in this life"* [1, p. 5]

In summary ergonomics stands for optimizing the work for people, therefor it is necessary to have a look on working conditions and processes as well as arrangements of objects. The goal is to optimize processes in that way that people do not get tired quickly during their work or even get hurt – considering the user friendliness. [1] On the effects of work regarding symptoms like stress, fatigue and other will further be discussed.

In the past tools have been adapted to humans over a long period of time based on scientific studies and ergonomic findings. [1] Nowadays solutions must be achieved faster with due regard to efficient use of resources which decreasing.

A number of studies show that the integration of ergonomic recommendations in everyday life is not a common phenomenon yet. There are many reasons described for example poor interest from the market, scare financial resources, a tight time schedule or insufficient ergonomic competence in the company. [2]

In the field of computer-based systems there are usually no long-term and evolutionary development processes. Today computer tools are subjected to a short life cycle and are dominated by economic instead of ergonomic principles. [1]

2.1. Software ergonomics

Software ergonomics is the theory of computer work and is dedicated to the usability of interactive computer systems. Interactivity is understood as the context of mutual influence of humans and computers. Depending on user-specific inputs or environmental conditions outputs are realized, whereby computer tools change their shape and function so computers show complex behaviour to the user. Just the retrieval of content from a website is not an interactive process. [1, 3, 4]

Software economics is inextricably linked to the hardware ergonomics, because software ergonomics is based on user- and application-oriented design of computer hardware.
Findings of software ergonomics are provided on different ways for example by laws, regulations, recommendations as well as design rules and tools. These findings are often violated or deliberately ignored particularly in working situations where computers are used. The consequences of this inexperience and ignorance are versatile for people who are working with computer. [1, 3]
Just to mention a few of the many effects: high temporal and personal effort to learn how to work with the software, the formation of indispensable experts or systems do not operate in the desired or usual form. [1, 4]
Often it is only realised by the end user that the usability of a system is low, even if the functionality is given per se. Usability, what can also be explained "user-friendliness", is characterized by effectiveness, efficiency and satisfaction of the user. Perceptions of psychology, informatics as well as sociology have an impact on the basis of usability. [5]
Software ergonomics is to be distinguished into interaction design and usability engineering. Interaction Design deals with the functional design, the behaviour and finishing of products and systems. Software ergonomics provides the interaction design criteria for the design. By contrast usability engineering ensure the usability of systems. [1, 3]

2.2. Work systems

ISO 6385 meant by a working system *„a system, which the interaction of single or multiple users for the work equipment to fulfil the function of the system within the working space and the work environment under the conditions prescribed by the tasks*“. [6, p. 6]

Work systems consist of both technical as well as social components. In this context, we speak of so-called sociotechnical systems. Sociotechnical systems can be seen in various contexts for example a user monitoring a display of train activities to an entire railway network. [7]
The technical part is composed of technical equipment, production materials, technical conditions and spatial conditions. The social sector is concerned with another individual and group-specific abilities and needs and their relationships. [1]

In the past computer technology was crucial to the work place design. Nowadays the focus is on the user that means that the human being performs tasks within the work system. The focus to the user means to adapt the technique to humans. This knowledge from psychology and physiology is essential to the development of computer systems to meet the people's needs. [1]

2.2.1. Components of work systems

Software ergonomics deals with all essential components of a work system (see Table 1) . Following, these will be descripted in detail.

Components of work systems
Operations, tasks and activities
Division of work
Work objects and states
Work equipment
Roles
Workflow
Workplace
Working conditions
Similar to work activities

TABLE 1 - COMPONENTS OF A WORK SYSTEM [1]

ISO 6385 meant by operations *„the organization and the temporal and spatial sequence of tasks of a person or the combination of the entire human labour actions of users in a work system. As part of the activities individual tasks arise. Tasks are necessary to achieve the objectives activities."* [6, p. 5]

In form of a task analysis tasks must be defined (e.g. objective, reason, content, conditions, emergency) to ensure the understanding and designing work systems.

For the system design, it is important to figure out external in internal tasks. [1] The definition of external or internal tasks can be easily explained with an example.

„The external object at the top level is writing a letter. The task consists mainly of the sub-tasks: provide a letter with the address, subject heading and writing *the actual content of the letter. Both are problem-related tasks are independent of used work equipment.*
The internal tasks arising from the external tasks are all tasks that arise in connection with the activation and use of computers and the text that run on the system to write the letter…" [1, p. 22].
The selection of the appropriate method of task analysis depends on the complexity and scope, like the hierarchical task analysis (HTA).

Humans and computers complement each other in a special way; each subsystem has its strengths and weaknesses. The strengths of people are in situations where problem-solving skills, flexibility, creativity or valuations are required. Computers distinguish in situations where extensive, well-defined, systematic and rapid analysis and reactions are necessary. [8]
The more tasks are explicitly analysed and defined, the better computers can handle tasks completely automated without humans. In case tasks cannot be described in detail, it is better to dedicate them to people. In practice the solution is often in between, computers take easily automated tasks, whereas humans devote to the rest of the tasks. [8]
It can be said that humans and machines complement each other perfectly because of their contrasting strengths. But not only humans and machines can share work, but also people among each other.

With work objects tasks are processed. Work objects are handled using tools such as functions or operations. When processing tasks the state of work objects change, starting with the work target to work result. Users have certain mental representations, so called mental models, with which they can imagine work. Work objects are an essential part of mental models. [1]

ISO 6385 meant by work equipment "*tools, including hard- and software, machines, vehicles, devices, furniture, fittings and other in the work system used (system-) components*". [6, p. 5]
To keep it simple, work equipment are aids or tools which help to perform work. Referring to software ergonomics work equipment is termed as computer-based work equipment

(application systems or programs). It is essential that work systems are usable and realised in regard of effectiveness, efficiency and satisfaction of the user. [1]

Division of labour takes place not only between humans and computers as described in section 2.3. Roles are described as organizational units that can be performed certain tasks alone or together. After completion of task analysis tasks are assigned to a role. [1]
So what is the best way to fill a position? The best way to fill a position is to make a decision based on the people's qualification. With respect to computer-based applications systems, it is important that people are able to operate the application system itself and have the expert knowledge to solve the task. [1]
It must be noted that interests and qualifications of persons can change over time, equally tasks and their structure change - therefore technology must adapt processes and not vice versa. [9]

ISO 6385 meant by workflow "*spatial and temporal sequences of interaction between workers / users, work equipment, materials, energy and information within a working system*". [6, p. 5] Process organization or workflow is defined as a specific sequence of activities. For example, work results of a processor are often the basis for further work tasks. [1]

The majority of computer work is done at fixed work places, which usually consists of a computer, table, chair, monitor... Of course, there are also numbers of other work equipment and tools, such as a telephone or writing materials. Due to its composition such jobs are also known as computer workstations or display workstations. [1]
A number of recommendations, guidelines and standards try to design the workplaces in that way that any damage injury can happen to employees. These include the alignment of workplaces and their work objects. [1]
Unfortunately many workplaces are poorly designed, so that workers have heavy losses in work productivity and are confronted with unnecessary injuries. [10]

Not only the structure and organisation of single workstations seems to be relevant, moreover the ensemble of environment and circumstances affect the performance, these include temperature, lighting or noise. In addition to the conditions relating to the activity itself, also social factors are decisive, in particular possibilities of interaction. Interaction can take place both internally with colleagues as well as with external customers. In this field it is a challenge to give people the opportunity to have social interactions with colleagues on the other hand, on the other hand other colleagues should not be disturbed in their working process, for example by loud calls, video conferencing, etc. [1, 3]

Basically, it can be distinguished between working conditions which have an influence on workers and personal conditions which affect the performance ability. The first group includes socio-economic, space-time, occupational and labour activity-specific working conditions. The personal conditions include familiar physical and psychological as well as current performances, which arise by the activity itself. [11]
Working conditions which were described above affect each other. They are not consistent in their appearance, for example through learning effects or improvement / degradation in performance. Some changes are predictable, others cannot be planned. [11]

Once the areas of life (work, free time and education) were clearly separated. Over time boundaries are becoming more and more unclear/undefined. Basically everything is always and everywhere possible. [1] For example through a variety of working models people are able to work at home and education is given at work.
The "traditional workplace" is increasingly becoming the past. By using digital and mobile media, work can also take place in other spatial and temporal contexts. It makes sense to transfer the knowledge of software ergonomics to other areas. [12]
Nowadays software ergonomics are not just concerned only with the design of interactive computer applications but also widespread with e-learning, e-commerce and even the design of computer games. Nevertheless, there still are mental and technological limits of software ergonomics that must be respected. [12]

It must be noted that the less work structures and work environments are defined in the meaning of a work system, the fewer recommendations in the interests of software ergonomics can be made. [1]
Not all recommendations are useful in all areas, for example, not everything has to be understandable in e-learning, if the target of the application design is to focus on independent development of many solutions is designed. [1]

2.3. Effects of labour

Work has not only positive effects such as the successful performance of work or getting results out of it, but also the negative effects on humans.
For decades the industrial psychology studies the effects of work, especially the special effects of computer work (see Table 2). [1, 11]

During the execution of work computer application users are polluted in a variety of ways. We have to distinguish between psychological and physiological strains.
Physical strains include discomfort in the area of the neck, shoulder or back, arms and hands, eyesight, hearing and not yet sufficiently explored stresses, such as electrostatic fields or electromagnetic radiation. The psychological strains influence areas of memory, attention, concentration, and the constant search and reorientation due to unclear or ever-changing function or information structures. [1, 13]
Stresses and strains are differentially perceived by humans and are dependent on personal performance. Once loads are perceived noticeable by people, they are referred to as stress. Stresses are not mandatory negative; they encourage mind and body to improve constantly. [1, 13]

Physical and mental growth is often mentioned in this context, which certainly have a positive effect on people like joy, motivation, performance improvement or acquisition of competence. If people are not able to handle such stressful situations negative effects arise.
Negative effects are emotional states such as fatigue, anger, frustration, or anxiety; but it can cause also psychosomatic or chronic diseases that manifest at work. [13] [9]

Software ergonomics is concerned with mental stress, a fact interesting to know for computer-assisted activities. Hardware ergonomic focuses on physical strains which can take place anytime or anywhere, and attempts to limit strains to a reasonable extent. [1]

Effects of labour
Mental fatigue
Monotony
Psychological saturation
Boredom
Reduced vigilance
Stress
Personality development
Social interactions

TABLE 2 - EFFECTS OF WORK [1]

Mental fatigue is described as *„reversible reduction in the efficiency of an organism as a result of activities“* [1, p. 39]. Physical signs of fatigue are e.g. elevated blood pressure and shallow breathing (hypoventilation). Psychological effects are a decrease of concentration and cognitive disorders. Fatigue can also be perceived subjective, especially when feelings of monotony, boredom or mental saturation occur together. [9, 13]

Mental fatigue can only be counteracted by exclusively pauses. Below in Figure 4 it can be seen that several short breaks are more effective instead of less but long breaks. [9]

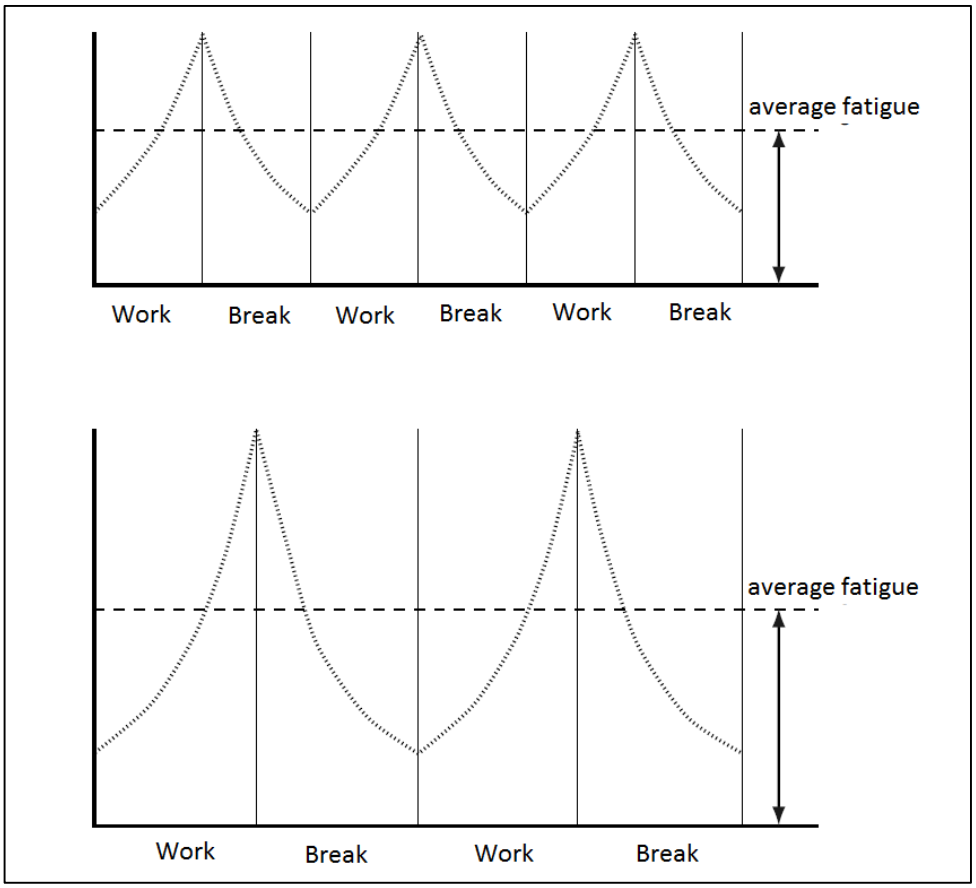

FIGURE 4- BREAK-WORK-BALANCE [1, P. 41]

There are several ways to describe monotony, for example as a kind of “semi-conscious state”, “the feeling to do always the same” or “insufficient mental strain”. [1] In general, monotonous work is equated with routine work, such as strictly defined task structure of agents. Also monotony is pronounced differently from individual to individual. Studies show that both monotone- vulnerable and monotone-resistant people exist and that these manifestations correlate positively with extroversion and introversion character images. To avoid monotony it is advisable to offer mixed activities or to expand areas of responsibility. Similarly, group work or activity changes can have a refreshing effect on people. [9]

Psychological saturation is often equated or confused with fatigue or monotony. The psychological saturation differs from the stresses described above, because in this case a strong aversion / dislike already exist to begin and/or continue work activity at all.

The only way to counteract against this strain is design toe work and work conditions in that form that work becomes more attractive and interesting. [9]

Boredom is a state of quantitative or qualitative mental under load of a person. Either people have too less to do or they are bored in their work so the work is no longer challenging them. Boredom can either be offset by more work or, probably the better option, their tasks can be extended with high-demanding tasks. [1]

Vigilance experts understood high attention and responsiveness under this term. This property is especially important for occupations in which it is necessary to wait for known or unknown events and then react accordingly. [1]
For long-lasting surveillance work vigilance decreases with time. Therefore it is necessary particularly in such occupations that vigilance reviewed at regular intervals and only a certain time is executed. [9]

Stress is a *"subjective state … arises from the fear that a strong aversive close in time and subjective prolonged situation cannot be avoided. The person expects that they will not be able (or will be) to influence the situation or address through the use of resources."* [1, p. 45] Stress is caused by several different factors. The degree of controllability, the importance of the temporal proximity and the degree of aversion seem to be very important to the stress-inducing situation. [14]
It has to be distinguished between short-term and long-term stress effects on humans. Short-term effects include helplessness, irritability, disorganization or increased consumption of stimulants like coffee or cigarettes. Longer-term effects include permanent irritability or nervousness, and psychosomatic complaints up to a heart attack. [14]
What is the best way to deal with stress? There are numerous methods to face a stressful situation. It is important to familiarize yourself with the situation and seek a high level of self-controlled work. It is also useful to look for social or technical assistance in form of team colleagues or aids. [14]

Personality development is promoted by mental stress that means demanding activities. Results from studies have shown that the degradation of intellectual performances is favoured by low mentally demanding requirements. [9]
It is clear, that decisions in the field of work design are important for the personal development and not to be underestimated. So complex computer applications are particularly conducive for intellectual developments. [1]

Social interactions influence the effects of work too. This involves, for example considerations of the design of work in an office, so that an interaction can be enabled with colleagues or external people. Social interaction is not only described as communication between two peers in a working space, but also increasingly technical means, for example telephone or e-mail. [1]

2.4. Mental, conceptual and technical models

Mental models are mental perceptions of users, who are working with computer system, of the area of work and application system itself. Each user has its own distinctive, personal mental model. The better application systems are adapted to the mental models of users, the faster and more efficient they can perform. Users do not have to know how the software and hardware is built in detail, it is sufficient that users get to know the functionality and the behaviour of the system quickly. [8]
System designers have mental models too, but they are usually more abstract and structured, so they refer to as conceptual models. The better the computer system is adapted to the mental model of the user, the more suitable is the system. The problem is that system designers frequently do not know the application areas relevant for users well enough. And vice versa users have no idea of the possibilities of a computer system.
For completeness at this point the technical model is mentioned. Basically it is the realization of the application system, the counterpart of the user's mental model. [8]

2.5. User and user classes

User classes consist of users who have similar properties. Before an interactive system can be developed, it is necessary to find user classes and describe them.

The characteristics of user classes reflect the mental models of individual users. It is important to ensure that specific goals, existing experiences and sensory-motor manufacturing as well as expectations and desires with respect to the existing or new system are considered. In order to ensure a high level of usability is a classification of organizational roles, level of experience, market segment as well as lifestyle and context advisable. [1]

2.5.1. Organization roll

The structural models in the respective companies are often the first way to classify rolls. Labourers, agents or managers are generally attributed to different areas of responsibility, attitudes and skills. Role descriptions in the direction of tasks, skills and processes are usually already available in great detail (for example, job advertisements). [1]

2.5.2. Experience

Another possibility to form user classes is to use the similar experience level, by using this way it is not necessary to make consideration for individual employees (unexperienced user, advanced user, experts and occasional users) Again it should be noted that users can go through various user classes during their working life. In an ideal situation an application system is built up gradually so that inexperienced users are not over challenged and advanced users are able to filter higher levels on their own. [1]

Unexperienced users start at a new job or start working with a new application system. It is important to ensure that so-called "unexperienced user" should not be overwhelmed with the entire system functionality but have contact initially with the core function so they can perform individual single tasks already by their own. After a certain time the core function should be complemented with further functions whereby the user develops with regular use to an advanced user. [1]

Advanced users are an important user class because in this group it is perfect to embed well designed work systems. In this area, the knowledge of software ergonomics can help the most. This user class is characterized among other things by a rigid knowledge of the

application, automatism and repetitive work sequences. Advanced users can call themselves as experts after years of experience with an unmodified application system. The prerequisite for this is that they are interested in the application, constantly trying to locate the boundaries and customize the program. Advanced users often got rare or difficult tasks to do which cannot be solved by routine skills. [1]

Occasional users use as the name suggests specific applications briefly or infrequently, for example time table information for trains. Precondition is that systems are simple, fast, and understandable to use. [1]

2.5.3. Market segment

In comparison to the classification groups described so far market segments are not so worthwhile, but they can be a starting point for further classifications. Market segments are interesting of the buying behaviour of a particular target group is needed, for example to frame appropriate marketing strategy. [1]

2.5.4. Life context and lifestyle

Besides buying behaviour it is a possibility to find characterizations of groups in society (ethnographic studies). In particular environmental studies, a special form of ethnographic studies, which describes social structures and ways of life that can give conclusions on technological interests / usability. [1]

2.5.5. Methods for analysing user

Less abstract classifications in comparison to the user classes described above can be achieved with stereotypes or personas. Stereotypes are representative of a group of users and provide a further specification of user classes. Prototypes, however, are more concrete than user classes, but the concretization depends on the viewer.

The disadvantage of stereotypes is that they are often rated negatively and involve the risk of prejudice/bias. So it can happen that people are described rather rated as representative. [15]

Further developments of stereotypes are so-called “Personas” where specific fictive users are described. Starting point is the analysis of a particular user, which is specific as to his knowledge, skills and goals. Personas are described credible by their biographical data, the description of the character, education and previous professional activities, experiences and expectations. To ensure that the personas not only appear comprehensible, but are also consistent with the real users, processes such as interviews, questionnaires or surveys are used. This is suggestive because both qualitative and quantitative analyses can be performed. [15]

2.6. Models for Human-Computer Systems

Generally there are two different approaches. Some models assume that humans and computers communicates with each other (Human-Computer Communication), others assume that people set actions in computer’s space of action (World or action models). [1, 16] Figure 5 shows the dimensions of human computer systems, interactivity and multimediality. Interactivity describes the interaction between humans and computers. The interaction can be understood as a dialogue using an appropriate language or as an exposure of acts. Multimediality describes over which medium interactivity can be made. [1, 16]

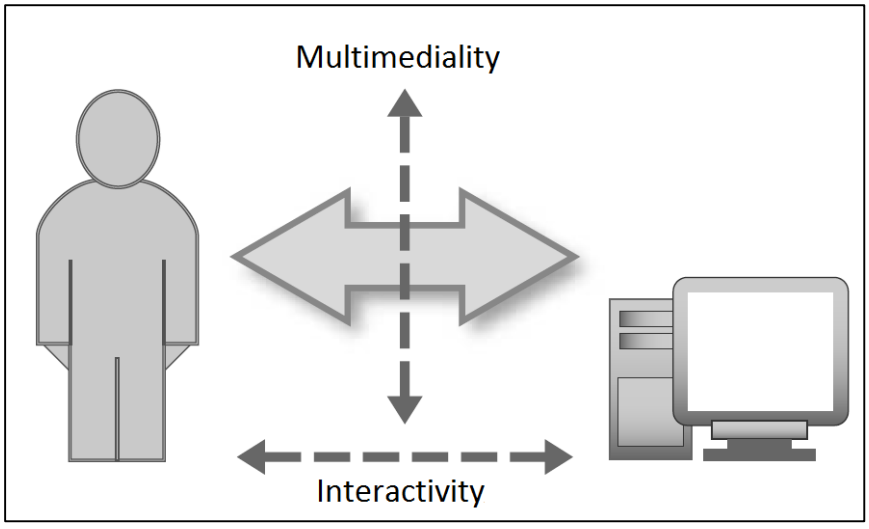

FIGURE 5 - DIMENSIONS OF HUMAN-COMPUTER-SYSTEMS [1, P. 114]

2.6.1. Communication systems

The communication model by Shannon and Weaver is a basic model of communication, which was taken over and over again as basis for subsequent models. This model focuses on information in the technical sense. The model shown in Figure 6 describes the communication between the transmitter and receiver over a potentially noisy channel. The transmitter sends an encrypted message from the channel to the receiver who decrypts the message. The language in which the communication shall be performed can be selected in principle. The goal is not only to communicate via command languages or character combinations, but also in spoken or written natural language. The computer as a communication partner is going to be increasingly humanized. [1]

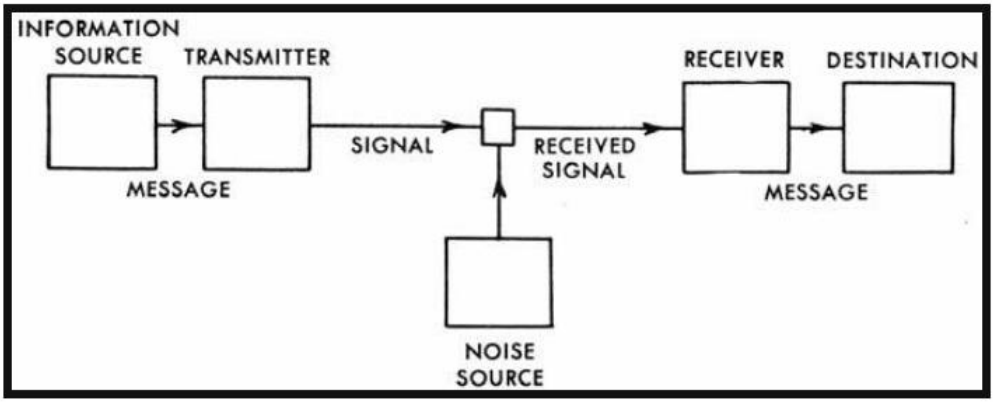

FIGURE 6 - COMMUNICATION MODEL BY SHANNON AND WEAVER [1, P. 117]

In order to understand processes of interaction the communication model of Shannon and Weaver is insufficient, so now the 6 levels model for communicating systems is used. [1]

6 levels model for communicating systems

The model shown in Figure 7 describes the communication between human and computer system. On the left side the generation and output is given; on the right side the detection/processing of the used language. The model is divided into several levels which are described in detail. [1]

Starting point of any planning is an intention, so the first level is named intentional level. Depending on the work results positive or negative reviews can arise. On the pragmatic level intentions are translated into goals which are tried to achieve with the help of learned procedures; whether the objectives have been achieved ultimately depends on the interpretation of the results. Procedures are performed with the available functions of the system. So on the semantic level objects can be created, modified or deleted. If the desired states from the output are not indicated, other functions must be used. The syntactic level specifies input rules, such functions are to be performed. It is necessary that the user gets an error in the computer output if the input wasn't correct, so the definition of input characters are described on the lexical level. By using key or buttons the user makes his entries, ultimately over motoric or spoken commands. These signals must then be recognized by the computer (sensomotoric level). [1]

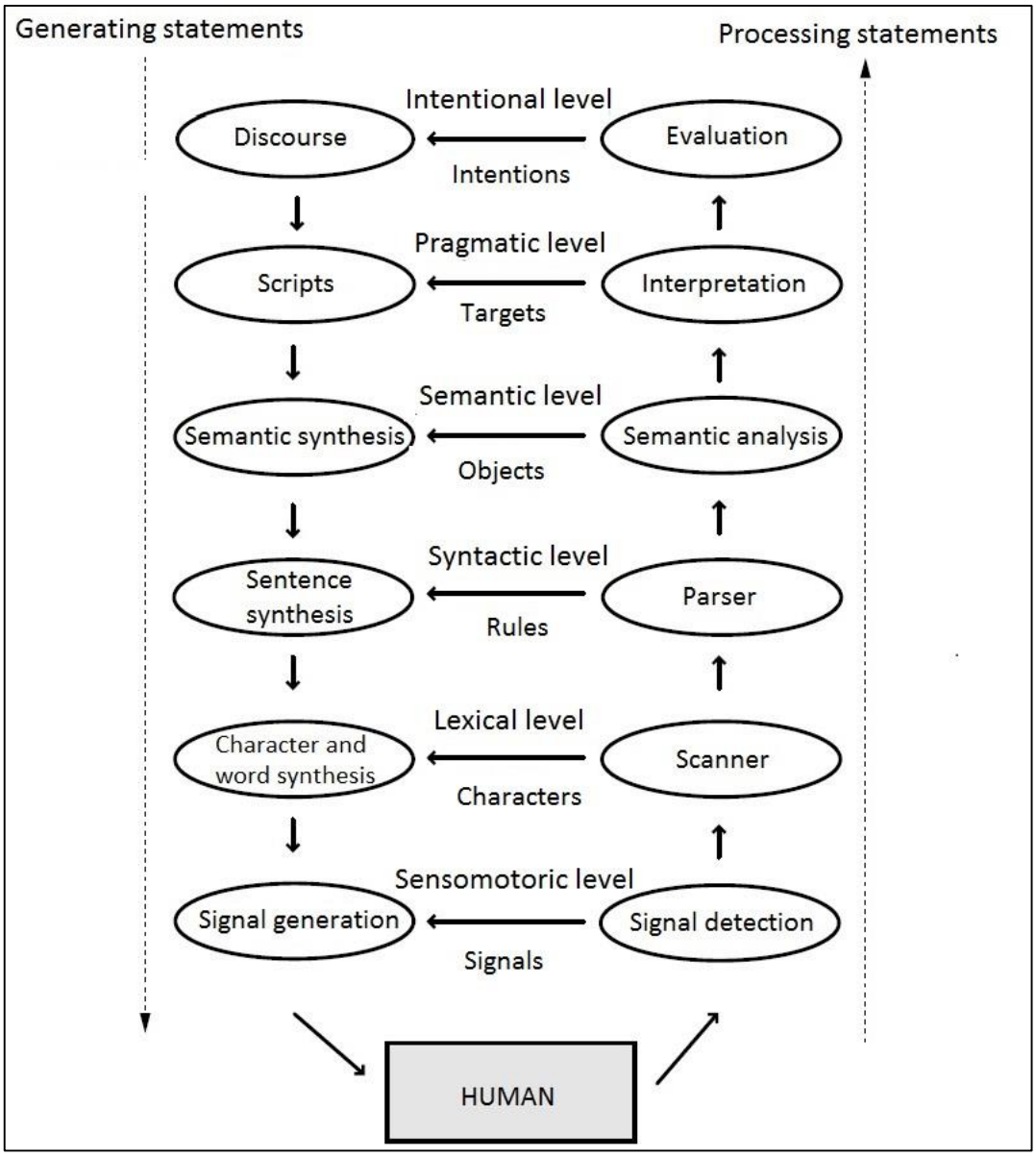

FIGURE 7 - 6 LEVELS MODEL FOR COMMUNICATION SYSTEMS [1, P. 121]

To use the natural language for human-computer communication has proven to be difficult. The main problem is the ambiguity of natural language and the difficulty of representing human knowledge in a computer. [1]

Generally there can be distinguished systems which recognize words, sentences of human language. There is a range between simple recognition of commands to complex language translators. [1]

2.6.2. Action systems

In contrast to communicating systems computer are understood as a space of action by the perspective of action systems. The action space can e.g. be a graphical user interface of a workstation (desktop) on which actions can be set through input and output devices. [1]

For humans it is natural to act in their environment using tools to create, change or eliminate objects. Analogous to computer-based action spaces objects can also be created or changed here. Functions are depicted pictorially concrete (e.g. symbol scissors or printer); in other cases the function is provided only with a name ("Cut," "Print"). [1]
The activity theory is characterised by activities within environment around objective and social structure, roles rules that influence users. Results of activities can be further activities. [1]

The model for human actions describes the transfer from targets for concrete actions and the perception of system outputs is considered to evaluation. As action regulation we understand the ability to perceive and in case needed to correct or supplement effects. [11]

The process management model of Rasmussen describes an action model which is tailored for monitoring and control of processes. Rasmussen believes that human perception and action take place principally at three levels namely automatized, rule-based or knowledge-based behaviour as can be seen in Figure 8. Automatized behaviour is characterized through a perception of signals which are largely automated implemented in reactions. If there are no automatism rules can be activated due to characters learned. If no rules are learned, the situation can only be overcome by trying to solve the problem (knowledge-based behaviour). Process management usually has a higher proportion of monitoring activities, which may eventually lead a reduced vigilance. [17]

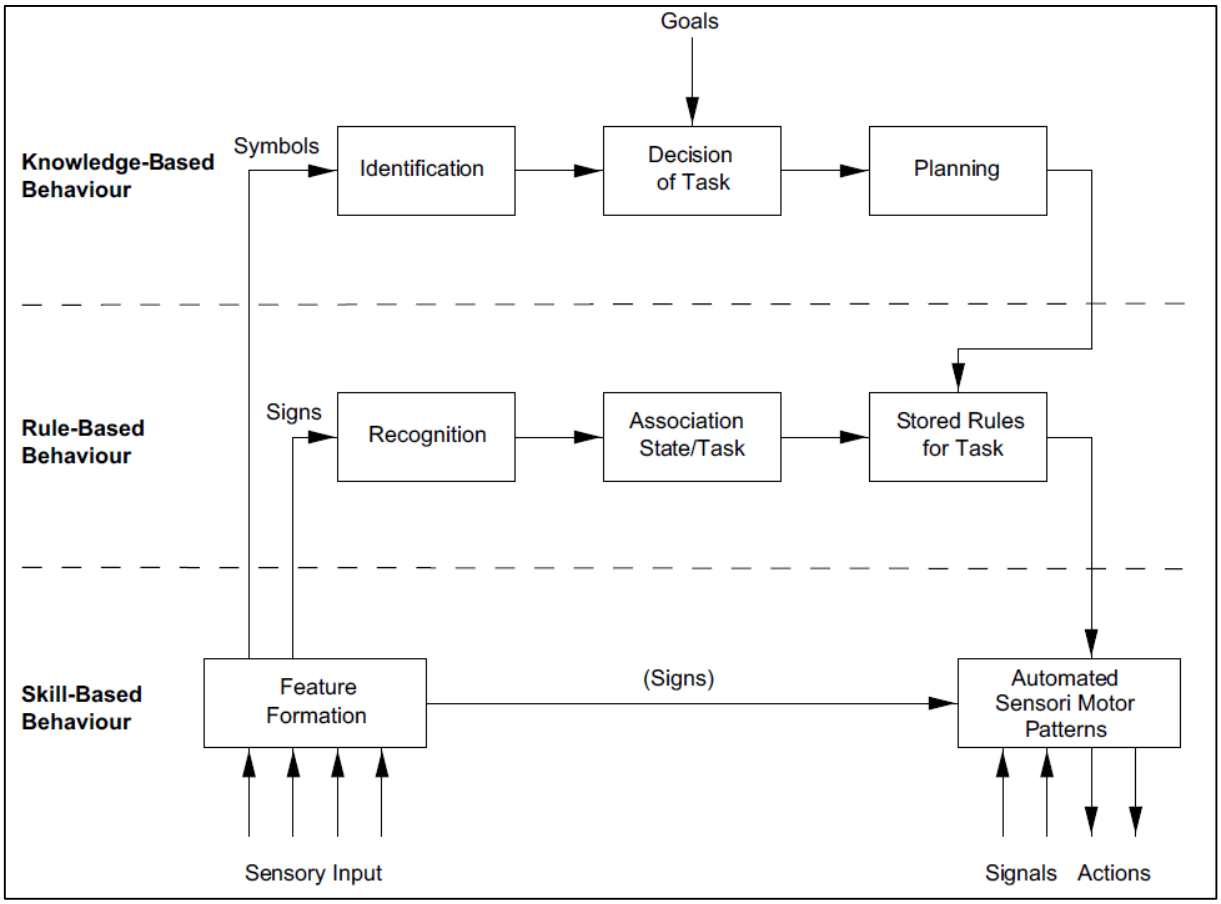

FIGURE 8 - PROCESS MANAGEMENT MODEL BY RASMUSSEN [1, P. 130]

6-level model for human action

The 6-level model for human action describes a human acting with a computer in terms of planning and implementation (left side), perception and change of system conditions (right side). To get a better understanding the six levels are shown in Figure 9 for illustration. [1]

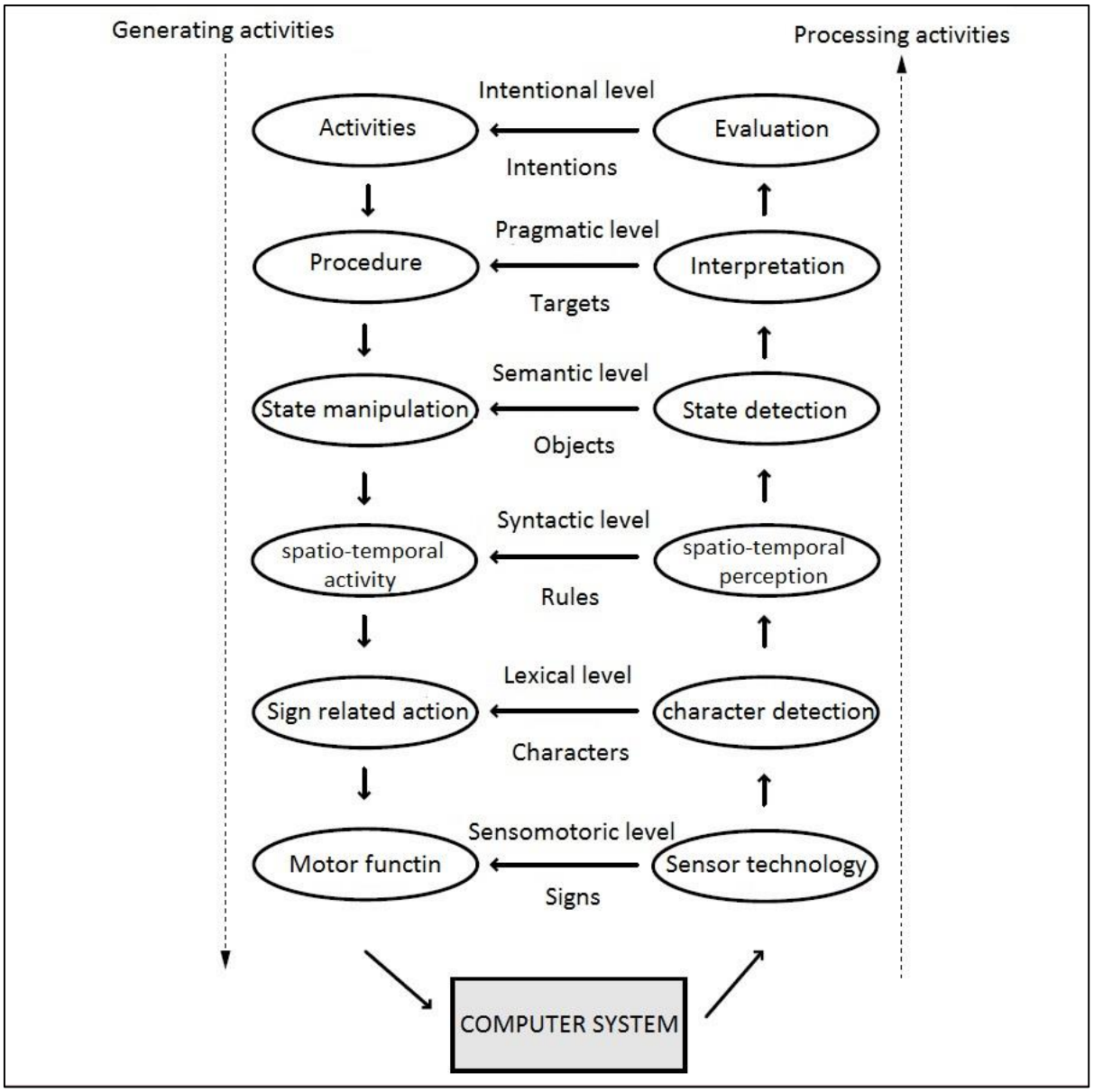

FIGURE 9 - 6 LEVEL MODEL FOR HUMAN ACTION [1, P. 134]

First the intentional level describes a task in relation to an activity. On the pragmatic level working processes are selected or developed. Working objects can change their state which are explained on the sematic level. On the syntactic level the transfer of manipulation in syntactic rules are shown. On the lexical level objects are represented in characters. Manipulation by sensomotoric activities (e.g. movement of the computer mouse) are on the sensomotoric level. [1]

The reaction of the computer system is also divided in six level and starts with the below stage. The sensomotoric level makes the response to human sensory. The perception of the change in characters are described in the lexical level, the spatio-temporal perception on the syntactic level. The change of object states are shown on the semantic level. The interpretation of the changes and derivation of the proposed act structure finds place on the pragmatic level. Finally the intentional level look if there are discrepancy between reached state and expectation. If there is no discrepancy the target state is reached. [1]

6-level model for action systems

Action systems construct object structures out of user's perceptions, which can be generated, changes or removed by users. Like above the 6 model for action systems is divided into six levels which can be seen in Figure 10. [1]

The semantic level defines system objects with properties that match the needs of the users. The pragmatic level support procedural and problem- oriented functions.

On the intentional level it is clarified whether the system is able to handle the tasks and thereby achieve the set goals. The syntactic level contains object-oriented control structures which explain the user how objects can be selected and manipulated. The lexical level represents the application objects in form of characters. The sensorimotor level, finally, ensures that objects can be moved and changed directly. [1]

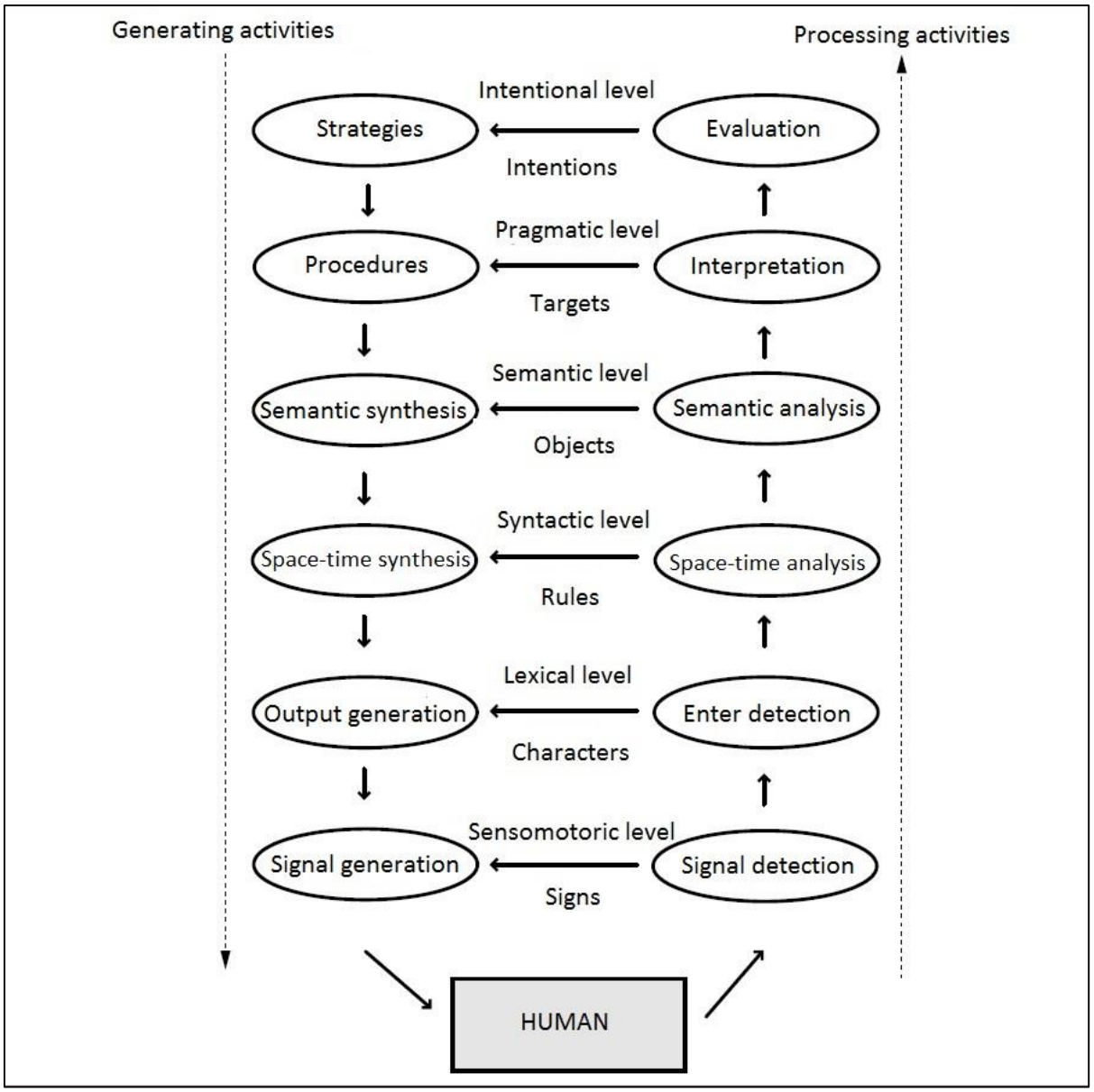

FIGURE 10 - 6 LEVEL MODEL FOR ACTION SYSTEMS [1, P. 135]

Examples of action-oriented systems are desktop systems which give user the impression that objects are easy to manipulate directly. System quality is influenced by direct manipulation, the directness of interaction and "deep involvement" in the application world.

Distances are differences between mental models and system models which require more effort from the user and can occur on all levels of the model of action. [1]

On the intentional level it can happen that there is only a partial overlap of the functionality of the application system and the user's task structure. A partial overlap can also appear on

the pragmatic level in connection with the measures which the user wants to use. Functions (objects and operators) of the application system often do not coincide with the mental models of the user (semantic level). On the syntactic level the interaction language which is used for entry of operations is often difficult. Distances can also occur on the lexical level, e.g. if user want to write German text in an English-speaking editor system (ä, ü, ö not available, but must be presented with ae, oe, ue). On the sensorimotor level it can happen that the physical output of the system does not correspond to the physical user input. For example a user can expect a synchronized reaction when using a computer mouse. [1]

In most cases Direct Manipulative Systems are action systems which try to reduce the perceived distance to a minimum. These systems provide users with a "sense of involvement" in the application world. It gives the impression that the application world can processed directly. Users get satisfaction and control of the application system. [1]

2.7. Time behaviour of interactive systems

In the interaction between humans and computers also time plays an important role because it has an impact on user's satisfaction and productivity. A delay during interaction leads to user's insecurity, anger and frustration. Conversely users are overwhelmed with too fast response times and work as a result of to quickly so error rates increase. It is necessary to ensure a good balance between human's reaction time and machines and the expectation of time behaviour. [1]

Interaction steps are divided in several periods. Input time is the duration of user input. The period between the end user input and system output is called planning time. In this timeframe the user is planning future steps depending on expected output. The reaction of a system is named response time. This time defined the time between user input and system output. The duration of the system output is called output time. The last period is the timeframe between system output and user input in which the user is thinking about further working steps (thinking time). [18]

Cognitive psychology helps to make decisions for the design of progress time. When output or response times are too long, there is the risk that users forget their work objectives partially

or completely. Due to long response times users are afraid of making mistakes and as a result of this they slow down their work performance. Conversely users may be overwhelmed with too short output or response times and will work as more intuitive than planned. [1]

The optimal time behaviour is often dependent on the wishes / preferences of users. For example, inexperienced users prefer slower response times because they prefer a slower performance per se as in contrast to routine users and experts. Clear and simple tasks with low potential sources of error are generally performed in a fast way. [18]

All factors described above can usually only be evaluated qualitatively. For evaluation purposes factors can also be evaluated quantitatively in well-defined systems. [1]

For computer systems mainly two parameters are relevant. First, the time required for a system to react to a given input (response time) and the duration of the output information itself (output time). The response time is affected by a number of parameters; some of them are not modifiable such as previous experience of users with similar systems or personal preferences. Activities that are time critical limit the response time to the top; computer performance and efforts limit the response time to bottom. [1]

Generally it is recommended that response times will keep less than 4 seconds, ideally less than 1 second. Except cases such as text entry in editors or settings in the cockpit of an airplane. In this cases much faster response times are required like under a second. Longer response times are possible, but should be communicated transparently and understandably for users so that events described above do not occur. [18]

Figure 11 shows that a favourable response time associated with a low error rate. Too short or long response times indicate increased faulty transactions. As already mentioned to long response times influence short-term memory; in turn too short response times lead to hasty, intuitive and not methodical action. [18]

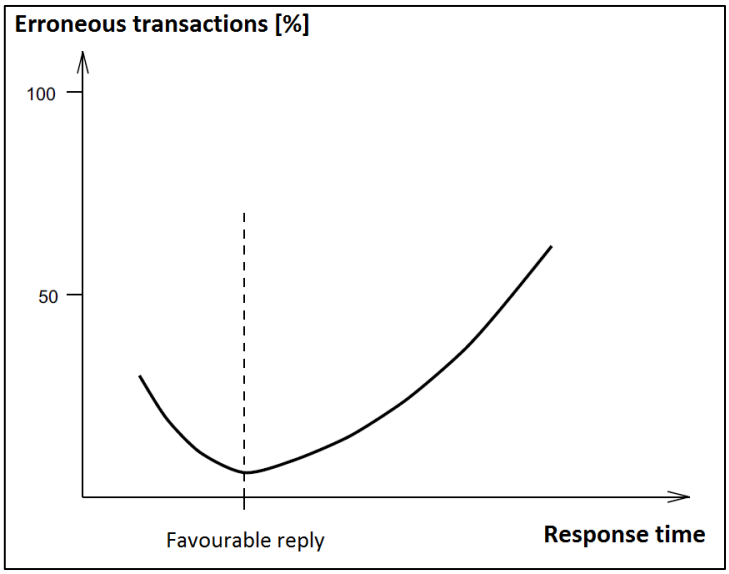

FIGURE 11 - CORRELATION BETWEEN RESPORNE TIME AND ERROR RATE [1, P. 151]

Output time is defined in cps[7] and varies from computer system to computer system. Studies have shown that an increase in the rate of spending from 10cps to 30cps the so-called "average think time" of the user was reduced, that means that the operating speed has increased. [1]

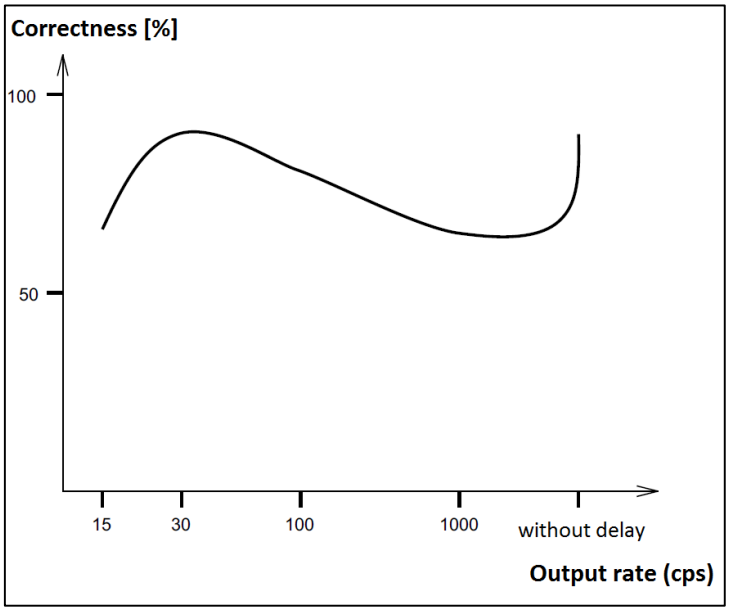

FIGURE 12 - CORRELATION BETWEEN OUTPUT RATE AND CORRECTNESS [1, P. 153]

[7] cps: Charecters per second

Figure 12 shows that the optimal output rate is about 30cps (reading speed) as well as subjectively delayed spending. [1]

2.8. *Software ergonomic quality criteria*

Level / Criteria	Intent. Level	Pragm. Level	Semant. Level	Syntac. Level	Lexical Level	Sensomot. Level
Effectiveness	X					
Efficiency		X	X	X	X	X
Satisfaction of users	X	X	X	X	X	X
Availability	X	X	X			
Reliability	X	X	X			
Reusability	X	X	X	X	X	X
Combinability	X	X	X	X	X	X
Expandability	X	X	X	X	X	X
Complexity	X	X	X	X	X	X
Transparency	X	X	X	X	X	X
Adequateness of tasks	X	X	X	X	X	X
Self-descriptiveness	X	X	X	X	X	X
Compliance of expectations		X	X	X	X	X
Learnability	X	X	X	X	X	X
Controllability				X	X	X
Fault tolerance		X	X	X	X	X
Individualization		X	X	X	X	X
Perceptibility				X	X	X
Readability				X	X	X
Discriminability					X	X
Clarity				X	X	
Orientation				X	X	X
Tractability of attention			X	X	X	X
Operability		X	X	X	X	X
Conduciveness						X
Multiple contexts	X	X	X	X		
Operating safety				X	X	X
Directness		X	X	X	X	X
Involvement			X	X	X	X
Naturalness			X	X	X	X
Intuitive operation	X	X	X	X	X	X

TABLE 3 - SOFTWARE ERGONOMIC QUALITY CRITERIA [1, P. 159]

Software ergonomic provides criteria which should facilitate the analysis, design and evaluation of interactive systems. There are many criteria that can be used generally as well

as application-specific. The list of criteria presented below cannot be regarded as complete, because in software ergonomics constantly new criteria are discussed. Have a look on Table 3 to see which criteria and quality characteristics occur on the different levels of human and computer interaction. [1]

2.8.1. IFIP Model

The IFIP model, seen on Figure 13 - IFIP model, was an early basis to order criteria from software ergonomics context. Many standards such as ISO 9241 used the perceptions of IFIP model as basis. Based on this model, the user interface is structured to a tool interface, a dialog interface, an input and output interface such as an organizational interface is. The different interfaces were assigned to individual criteria. [1]

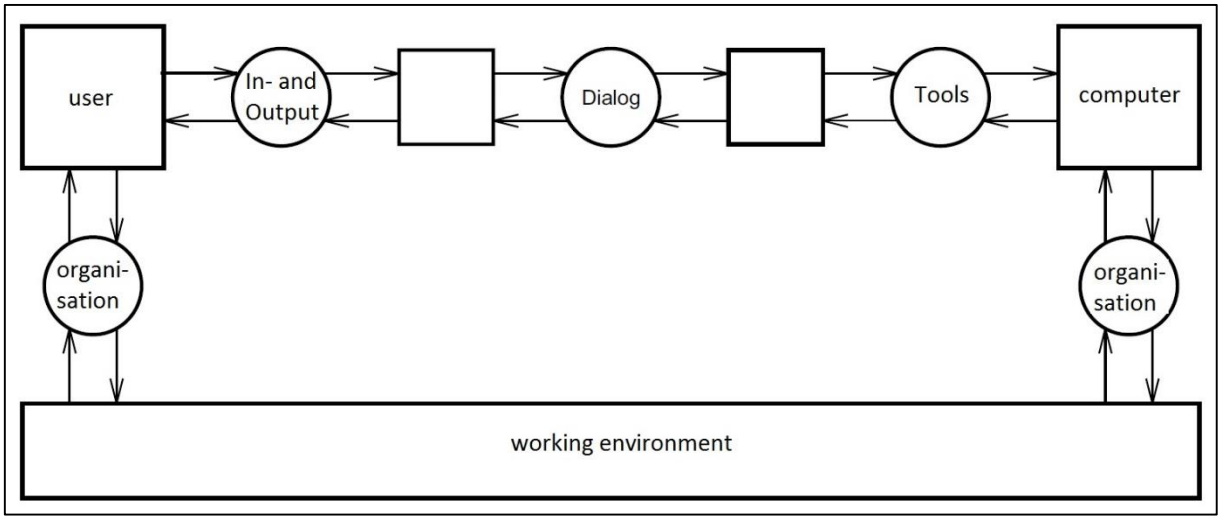

FIGURE 13 - IFIP MODEL [1, P. 157]

2.8.2. Criteria for the usability of systems

It was already mentioned that the term usability is described through the components effectiveness, efficiency and satisfaction of user and are explained in detail below.

Effectiveness refers to the complete and correct execution of an activity respectively *"the accuracy and completeness with which users achieve a specific destination"*. [19, p. 4]

Efficiency is given when user achieve their goals without making unnecessary activities. So the question is whether the user can perform system tasks with little effort reliably. Another definition describes efficiency as *"the relation between accuracy and completeness to the inserted effort to achieve a special goal".* [19, p. 4]

Satisfaction of users are described as "*freedom of impairments and positive attitudes towards the use of a product*". [19, p. 4] So satisfaction is a subjective reaction which is influenced by many environment variables. Satisfaction is influenced by the experience of the user as well as the introduction strategy of an application system. [1, 20]

2.8.3. Criteria for functionality of systems

Criteria for functionality are listed in Table 4. They are described in detail below.

Criteria for functionality of systems
Availability
Reliability
Reusability
Boredom
Combinability
Expandability
Complexityy
Transparency

TABLE 4 - CRITERIA FOR FUNTIONALITY OF SYSTEMS

System functionality is not available anytime or in every context. Sometimes user have to prepare system's states to use the function they want. The availability of a system functionality also depends on technical conditions like system errors, physical environment situations like temperature or time conditions [1]

After user activate a system and select an appropriate function, they expect to achieve a corresponding reliable result. If the expected reliability of a system is not present, the user has to be informed. [1]

If user have learned to work with a system and to handle its work objects, they prefer that the learned knowledge can be applied to other areas. For example signs shall have the same meaning everywhere. The symbol scissors means the function "cut out" of objects or information. [1]

A combination of simple functions can lead to complex functions. Functions should be combined to processes like procedures or macros, objects should be built to complex objects or a hierarchy of objects and so on. Because of combinability systems become user-specific, application-specific or context-specific. This criterion is especially interesting for routine users and experts. [1]

The combination of constructs are an expansion and adaption to system's tasks. Sometimes user want to create new objects or functions which results in an extension on the currently system. By use of programming every software system can be extended but this is normally not available for end user. [1]

Complexity should not be confused with complicatedness. Complicatedness refers to the unnecessary overload of a system with functions and features. In contrast complexity describes size, structure and functionality of an application system. Complexity can appear in many applications and sometimes it is not possible to get around, whereas complicatedness should be avoided. [1]

Sometimes users understand transparency as the clarity of a system in terms of structure, function or operability. Customers perceive systems as transparent when they think they have understood the system and feel they are able to guess behaviour. [1]

2.8.4. Criteria of the quality of a system in terms of interactivity

The criteria listed in Table 5 are less about the functionality of the system itself, but about the interaction between user and objects respectively functions of a system. The criteria described below are not independent of each other and influence each other partially.

Criteria of the quality of a system in terms of interactivity
Adequateness of tasks
Self-descriptiveness
Compliance of expectations
Learnability
Controllability
Fault tolerance
Individualization

TABLE 5 - CRITERIA OF THE QUALITY OF A SYSTEM IN TERMS OF INTERACTIVITY

"*An interactive system is task adequate if it helps the user to do its task that means when functionality and dialogue are based on the task's characteristics, rather than on the used technology*". [21, p. 8] In this area it is important that the user is not burdened with unnecessary information and can have its focus on the essentials things most of all in time-critical situations. Otherwise the work performance begins to suffer. It can be seen that this criterion is closely related to the effectiveness and efficiency of a system. The criterion shows that software ergonomics dot not only adapt systems to users but also the specific tasks. [1]

A dialogue is self- descriptiveness when users are able to understand at any time which dialogue they are using and which actions can be performed and how. [21]
Ideally, user interfaces are obvious, so that even un- experienced users can work quickly with the system. In most cases, however, specific training or interactive assistance is needed. [1]

Compliance of expectations is understood as the rate of accordance between user's mental models and a working system. In this area consistence is also important because inconsistent

systems prohibit the generation of transparent mental models of a system. For example expected response times are relevant in this context. If long response times can be predicted, they must be communicate to the user so that no uncertainty arise in the usage of the application. [1]

Learnability is the competence of a dialogue to support the user by learning and introducing an interactive system. [21] Especially for learnability it is necessary to differentiate the user's experience. Nowadays, there are hardly interactive systems that meet this criterion, ideally systems are understandable immediately. [1]

The dialogue control can switch between human and computer. The interaction can be distinguished into three dialogues, namely system-driven dialogue, user-driven dialogue and mixed dialogue. In almost all interactive systems are mixed dialogs. The control can be changed by the system or the user. The part which is in control can start the dialogue and make changes in direction and speed until the goal is reached. [1]

In the interaction between humans and computers user errors may occur. A system is fault-tolerant "*if the intended working result can be achieved despite of errors either with no or minimal correction effort on the user's side*". [21, p. 14] Fault tolerance is achieved when error detection, avoidance, correction or management are available. It is recommended that automatic fixes in the sense of fault management are shown to the user so that an interruption of work is not necessary. Equally erroneous entries must be designed so that it draws the user's attention. [1]

"*A dialog is customizable if users have the possibility to change the human-system interaction and the presentation of information in order to adapt them to their individual abilities and needs*". [21, p. 15] In practice, individualization is often undesirable or impossible. [1]

2.8.5. Input and output criteria

Another important issue are the user's input and the system's output. The refered criteria are listed in Table 6 and will be discussed in this section.

Input and output criteria
Perceptibility
Readability
Discriminability
Clarity
Tractability of attention
Operability
Conduciveness

TABLE 6 - INPUT AND OUTPUT CRITERIA

The perception of information usually runs unconsciously so this criterion can only be modelled partially. Standards such as ISO 9241 provide recommendations and guidelines how to design information. Also the avoidance of reflections or references with respect to minimum values for brightness, contrast or volume are described for example. [1]

Readability of characters and texts results of specific perception laws but also of character size or shape or other attitudes. Regarding the text representation, there are some recommendations from the field of computer typography. For example characters must be obvious and clear or the height of the uppercase letters must be at least 7 pixels. Such recommendations are limited to mobile or special devices. [1]

Different representations must be discriminable to the user. Discriminability refers to all the different representations on screens such as lines, patterns, sounds and tactile differences. So this criterion covers all representations not only characters and texts like readability. [1]

This criterion describes the arrangement and presentation of information, especially on computer screens in terms of shape, colour and layout. The clarity is a prerequisite for a better subjective orientation in the software environment. [1]

Orientation describes the property to give the user an overview of functional and object structures of a system. The placement of information such as the consistence, presentation and environment are very important. Especially for small mobile systems the orientation within the system is often difficult to achieve. An attempt is to shift or zoom contents to have a better orientation. By scrolling, enlarging or minimising content it is possible to increase the orientation within the system too. [1]

In many systems it is important to lead the user's attention to certain content or objects to achieve specific goas such as colour, blinking or tones. This criterion is especially important by systems which monitor activities over long time and where quick human reactions are needed if for example a critical states changed. So it is important to know how to focus the user on specific contents. [1]

In contrast to the previously described criteria operability is a criterion which focus on the user's input. Operability is related to input devices such as mouse or keyboard and describes how good they are appropriate for the application to perform tasks. [1]

Conduciveness describes the extent of negative effects of input and output devices. The Occupational Safety and Health Act contain many provisions. However, it must be noted that even when all companies are compliant to the regulations negative effects cannot be prevented completely. [1]

3. Data collection with Focus groups

The sense of focus groups is to gather information to better understand how people feel, think about a topic, in short what opinion they have. In this sense, focus groups do not differ from individual interviews. So, it could be concluded, that focus groups are a lot of individual interviews taking place ate die same time. However, focus groups are not a way to get as quickly as possible many interview partners, because interviews with groups differ from individual interviews on that basics, because focus group obtain data especially from the interaction of the participants.

It is important to consider that not every topic is suitable to be elaborated in focus groups. Especially sensitive or intimate issues could be inappropriate, because sometime people can talk about such topics in a group. In that cases individual interviews are more appropriate.

Another important factor in focus groups is the role of the interviewer. The role differs strongly between focus groups and individual interviews. The interviewer has to assume the role of a moderator, he has to guide the discussion and take care that every participating person get a chance to speak. [22]

3.1. Characteristics of focus groups

There are specific criteria how to set a focus group together? People are selected to participate in a focus group when they have certain properties that are related to the research question. Most of them have something in common (knowledge, a common experience or are experts in a particular field). The optimal size of focus groups is between six to ten participants. If the group is too small, there is a risk that the discussion is not in the transitions coming. If the number of participants is too large, it is difficult to conduct the discussion and to ensure that everyone get a chance to speak. Focus groups are, as mentioned above, guided by a moderator. He has to ask initial questions, to instigate the discussion, to sustain existing conversations and to moderate. In general, the discussion focused using a guideline, which is called script in focus group research. The script contains the time for how long a topic will be discussed. If this time is reached, it is the job of the moderator, to change the current topic. The duration of focus groups is, compared to other qualitative data collection methods,

relatively long. A useful duration of a focus group is two to three hour. At the end of a focus group should be enough time available to reflect and summarize the discussion together. [22, 23, 24]

3.2. Planning of Focus Groups

At the beginning of the planning if Focus Groups, the potential participants are in focus. Classical quantitative surveys are looking for a representative sample. Focus Groups are consists of a determined group of people, to get a "snapshot" of the reality. As participants, either artificial as well as natural groups are suitable. Artificial groups arise out of common experiences while a natural groups also have similarities outside the Focus Group. Participants can either be similar in their essential characteristics, what means they form a homogenous group, or they differ in relevant properties and therefore form a heterogeneous group.

Unlike in single interviews, in Focus Groups server voices can be heard simultaneously. Therefore is important to find a quiet location, to ensure a good sound quality on records.

The developed script mentioned before can assure that all Focus groups have the same sequence and it makes the discussion comparable between different groups. It also allows a discussion between different researchers before Focus Groups take place. So possible weaknesses can be eliminated beforehand.

In the course of conducting Focus Groups different media can be used, such as flip charts or digital media like PowerPoint. At least, It two researchers should always be present. Thus, one person can moderate, while the other person can take notes about the course of the discusion. [22, 23, 24]

3.3. Accomplish Focus Groups

There are certain personal attributes or skills that are important for the leadership of qualitative interviews as well as moderating focus groups. These includes respect for the participants, the understanding of the view of the participants, a basic understanding of the underlying research topic and giving all participants the feeling, that anything can be. The challenge with focus groups is to handle the high number of participants. Thus, it is difficult to

focus on a single person on the one hand, but on the other hand the moderator has to integrate each participant.

Just before the start of Focus Groups, it is important that the moderator is focused on his tasks and repeats his planning schedule again. The questions asked may not must interrupt the course of the discussion, reading from a crib sheet can trigger a question-answer behaviour. Another important preparation task is to check all recording devices and all required materials like pens and notepads.

The first minutes are reserved for the introduction of the research team, the explanation of the topic and discussion rules. After that, all participants have to introduce themselves and their connection to the topic.

During the discussion it is important to be prepared that participants may deviate from the topic or even come to a question that was not asked yet. In that case, the moderator has to intervene to get back to the original topic.

Focus Groups often consists of several different characters. Thereby is can happen, that some participants talk little or not at all and the moderator has to find a way to integrate them in the discussion. An opportunity is animating them through frequently eye contact or asking direct questions. Another typical character are participants who talks very much. In order that the discussion do not become a monologue, the moderator has to draw the attention to other participants. It is also important to make clear, that everyone's opinion is important and relevant for the research.

At the end of focus groups, the moderator has to summarize the discussion and all participant should have the possibility to add statements. Finally all participant get information about the further course of the survey and how they get the results. [22, 23, 24]

3.4. Evaluation of Focus Groups

After the course of Focus Groups, all visual materials of the discussion has to be photographed for later evaluation methods. These are additions to the transcribed discussion. There are several approaches for evaluating Focus Groups, and no one is the "correct one". It depends on the purpose of the study which approach is the right one. [22]

4. Content analysis

Focus groups as a qualitative data collection method, normally be evaluated with qualitative evaluation methods. Nevertheless, social scientists still work mostly within the positivistic paradigm, therefore it is necessary to test hypotheses with statistical methods, even so in the Ge:MMas project. Now, the aim is to transform qualitative into quantitative. Based on the content analysis by Mayring, Figure 14 shows five steps to get achieve that aim. [25]

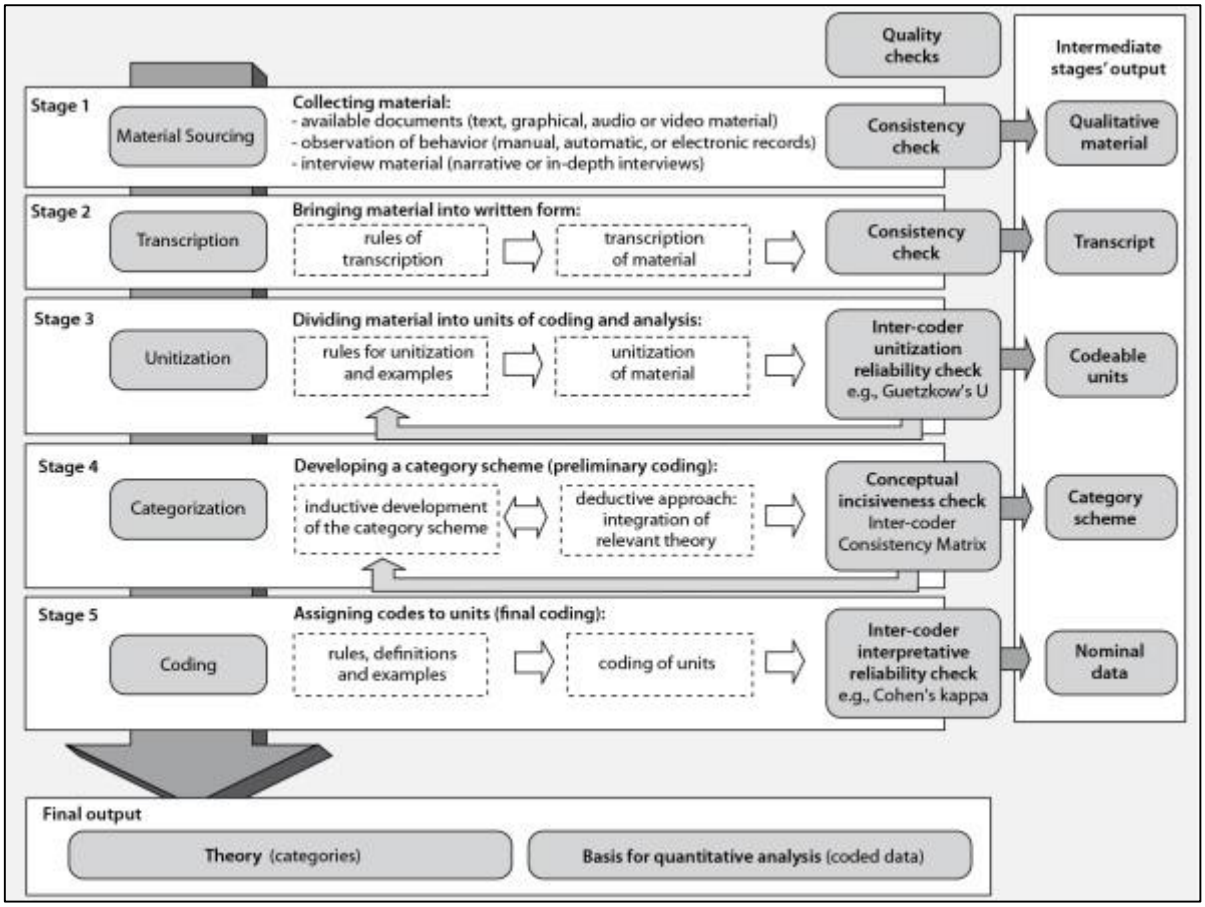

FIGURE 14 - TRANSFORM QUALITATIVE INTO QUANTITATIVE DATA [25, P. 35]

4.1. Material sourcing

The range of methods to get qualitative data is big. Figure 14 gives some examples, like observation of human behavior, interviews or the collection of available documents. As already mentioned, this work deal with Focus Groups as material sourcing approach. [25]

4.2. Transcription

A major problem when transcript data are language differences. Gathering and analyzing data in the own language of the responder highest validity, because language itself reflects cultural phenomena and particularities. Collecting the data in different languages is very time-consuming and costly however, because it need multi-lingual researchers or researchers from different countries to do high quality translations of the data. [25]

Another important factor is to detect non-verbal expression, like intonation, facial expressions or gestures, and make notes about it. Depending in the researching are, that inputs can be important issues. [26]

4.3. Unitization

It is important to define the unit of analysis to make systematic analysis of the data. In many studies, the definition of the unit evolves implicitly, therefore an explicit determination is not necessary. The unit is the basis for coding and further analysis. Which granularity will be the best for unitization depends on the data and the research objective. If the sources providing data in form of closed word associations or short statements, they mostly can be used as unit without any adaptions. If the data are only available in form of longer text and statements (like mostly in Focus Groups), the text has to be divided in predefined unit. As the best basis for analysis, so called “sense units” are a common unit granularity. The difficulty here is, that one sense or idea can be communicated in different ways, like a sentence, a single word or non-verbal expression. Therefore it is important, to note that or non-verbal expression during the transcription. [25]

4.4. Categorization

The next step is to refer units to categories. Categorization is a central process in part of a content analysis, to make the evaluation comprehensible. [27]

Categorization itself is maybe the most difficult part in the evaluation, you need a consolidated knowledge about the researched topic as well as a creative way of working. There are several issues researchers have to think about before developing a categorization schema. First they have to decide, how much of the unitized material should be used. Another point is the

structure of the categorization schema, should they use existing categories or new ones (or a mix of both) and how should the granularity and the hierarchy of the scheme look like. [25] Generally, would be an advantage to use the entire data or at least most of it. That helps not to lose relevant contents of the material. Another good approach is to build the categories in a deductive-inductive way, what mean to predefine categories deductive and complement them inductive out of the material. The granularity can induct a lot of problems. On one hand, a precise category scheme can bring the best information out of the material, on the other hand it makes the coding harder and, in case of two researchers, it leads to lower intercoder reliability (what is a quality criteria and will be discussed in point 4.6). Category schemes can be built as hierarchy as well as single level structure. This decision depends very much on the subject of research, but general a hierarchical form makes it more comprehensible. Sometimes, a hierarchy accrues during the evaluation process, sometimes researches are not satisfied with the granularity, and then they find subcategories or summaries subcategories to a new main category. [25, 27]

4.5. Coding

Coding is the process when all units gets related to a category of the defined category schema. Every unit get a code, like a number, what relates to a specific category. It is important to follow rules, how this assignment should be enforced. [25]

4.6. Quality criteria

A common way to increase the quality of qualitative evaluations is to involve several researchers, at least it should be two. More researchers increases the rate of objectivity of the results. Associated with the content analysis evaluations steps mentioned before, Guetzkow`s U as unitizing reliability and Cohen's kappa as interpretative reliability for coding are common quality criteria. [25]

4.6.1. Guetzkow's U

Guetzkow's U is a measure for the reliability between two researchers when they unitize a text. Both investigators have to unitize the data, independently from each other. After a first

try, they have to calculate Guetzkow's U based on the numbers of units with the following formula: [25]

$$U = (O1 - O2) / (O1 + O2)$$

, whereby O1 and O2 represents the both investigators.

If there's perfect agreement in the number, U will be 0. It's a measure of disagreement rather than agreement, so lower is better. If the agreement is not good enough, the investigator should rework their rules of unitizing and repeat calculation Guetzkow's U.

4.6.2. Cohen's kappa

A common tool to determine the quality of a category scheme and their rule catalogue is Cohen's kappa. As example, Figure 15 shows a cross-table with the results of two coders, coder 1 as columns and coder 2 as rows. This matrix represents intercoder classification correspondence rates for categories of the predefined categorization schema. Systematic inconsistencies in this matrix are indicates for problems in the process of coding. So, it is possible that coders interpret units differently, that the category scheme should be overworked or coding rules are not precise enough. Cohen's kappa can be calculated with this matrix and the following formula:

$$\kappa = (\Sigma Pii - \Sigma Pi \times Pi) / (1 - \Sigma Pi \times Pi)$$

, whereby Σ Pii is the observed proportion of agreement, Σ Pi x Pi the chance proportion of agreement. [25]

The result for Cohen's kappa is a value less than 1.0, whereby a value greater than 0.75 is specified as very good. [28]

Coder 1/ Coder 2	Cat. 1	Cat. 2	Cat. 3	...					Cat. n
Cat. 1	401	51	11	0	18	1	12	0	0
Cat. 2	23	430	44	0	25	2	18	1	1
Cat. 3	5	114	85	0	12	0	6	0	0
...	0	0	0	683	0	0	0	0	0
	9	61	62	0	86	3	12	0	2
	1	51	3	0	1	58	5	2	0
	2	40	16	3	1	1	372	3	1
	1	14	2	2	0	2	6	121	0
Cat. n	4	10	1	0	0	0	0	1	82
Total	446	771	224	688	143	67	431	128	86
Agreement	**74%**	**48%**	**23%**	**99%**	**29%**	**45%**	**74%**	**77%**	**77%**

FIGURE 15 - COHENS KAPPA – MATRIX [25, P. 45]

4.7. Computer-aided evaluation

Computer programs developed which support researchers evaluating qualitative data are called QDA-software[8]. These tools especially facilitates sorting, structuring and analysing big data and the administration of source material. Examples for common QDA-software are ATLAS.Ti and MAXQDA. [29, 30, 31]

[8] QDA: Qualitative data analysis

5. Results

This chapter contains the evaluation results of Focus Groups conducted in course of Ge:MMaS. The evaluation occurred in collaboration between me, Alfred Haidenbauer, and Dipl. Ing. Siegfried Sharma, who was also part of the Ge:MMaS project staff. Associated project reports are listed in appendix A.

The used evaluation process, based on the content analysis approach mentioned in chapter 4, will be described in detail. Figure 16 illustrates the procedure of evaluation, in the following sections the individual phases are described in detail.

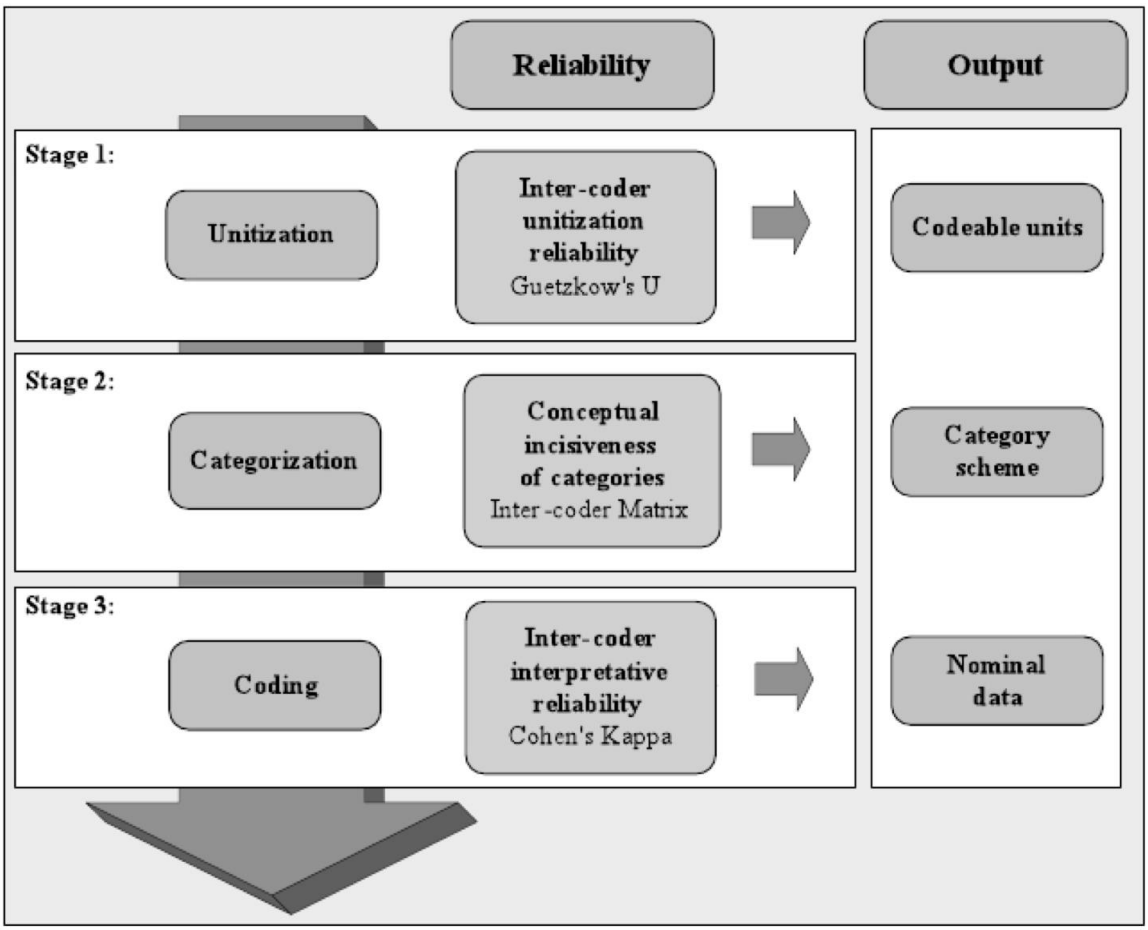

FIGURE 16 - USED EVALUATION APPROACH [32, P. 2]

5.1. Research questions

The aim of this work is to find answers of the following research questions:

1. What are the different user requirements between the selected user groups in their daily routines witch Trotec laser engraving systems?
2. Is the data collection and evaluation approach useful for finding user requirements?

5.2. User groups

As already mentioned, Focus Groups were held in the course of Ge:MMaS. Laser engraving systems, as the research field of Ge:MMaS, has a big user group which are directly work and interact with the machines and controlling software. Since Ge:MMaS investigates gender differences, this user groups has been further divided in female and male users. Beside individuals that are working with the system, with supervisors another interesting user group could be identified. With the assumption that supervisor needs are not gender-dependent, there is no further distinction of supervisors according to their gender. So, there are three user groups defined for three Focus Groups: male users, female users and supervisors.

The Focus Groups occurred in course of a daily workshop. The participants were german-speaking people from Austria, Germany and Switzerland. The female group consists of 9, the male group of 5 and the supervisor group of 6 participants. The duration of each Focus Group was about two hours. An overview about all Focus Groups and the transcription of them is shown in Table 7.

	Female users	Male users	Supervisors
Participants	9	5	6
Duration	2 hours	2 hours	2 hours
Transcription	52 pages	67 pages	77 pages
	22,425 words	23,233 words	28,335 words

TABLE 7 - OVERVIEW ABOUT THE FOCUS GROUPS

5.3. Transcription

To recording each of the focus groups audio and video records were used. To avoid interference and, for example, acoustic shadow of participants, recording devices were placed

on different places to get recordings from several perspectives. From that recorded data, transcript were created. All data sources were consulted to create the three transcripts of the Focus Groups. Since one source provided a perfect quality, other sources were users for validation. Furthermore transcription rules were applied, for example different punctuation mark for different durations of pauses in the discussion. Also emotions and other aspects of behaviour were detected and transcript, as seen on Figure 17. For validation of this raw material, both investigators transcript with different soft- and hardware support. Thus made it possible to gather nearly all information, except a few abstruse passages, like two concurrent conversations. The application of the rules resulted in 52 pages with 22,425 words and 116,382 punctuation for the female users, 67 pages with 23,233 words and 137,945 punctuation for the male users and 77 pages with 28,335 words and 148. 450 punctuation for the supervisors.

Reasons for the differences in the material scope are different types of conversational behavior as well as different speech rates. The significantly higher transcript levels in the group of supervisors resulting from occurring multiple simultaneous conversations, interruptions and consent of the participants.

TTi, gl:	[lacht]
JAu, w:	(..)
BBi:	Ja, also da probiert man herum und bekommt nichts Ordentliches hin oder? Das ist vielleicht, das wäre schön, wenn man da irgendwie Zugriff hätte direkt bei Trotec.
EHa:	Also das geht schon durch die ganze Kollegschaft, das stelle ich also auch fest. Hatte erst letzte Woche ein Telefonat mit einem Kollegen, der musste Stein gravieren. Und ich kann doch keinen Stein gravieren, hat mein Sohn gesagt. Dann mache es doch mit dem Laser, ja kann man das?
BBi :	Ja sicher
OKo:	[nickt zustimmend zu „ja sicher“] Klar

FIGURE 17 - TRANSCRIPTION EXAMPLE[9]

[9] For all transcripts please ask at the Department of Labour Science and Organization at the Institute of Management Science of the Vienna University of Technology or at the author

5.4. Unitization

First step in evaluating the transcribed data material was divided into units. As suitable granularity “units of meaning” were determined, because that level of detail and information content was the best basis for the research objectives. This process was executed by both researchers, to ensure an appropriate quality of the results. First step was to unitize the first 10% of the data of all groups (women, men and supervisors). Afterwards both investigators took place to check their sub results using Guetzkow’s U as reliability validation. Under an agreement of 91%, the biggest differences between the units of the both investigators were detected and the unitization rules were adapted. With an agreement over 91%, the investigators reviewed the last differences and agreed on a common result. The same procedure occurred for the remaining material. Here Guetzkow’s U was applied too, as seen in Table 8. At the end, 2140 Units for the group of female users, 3024 units for the group of male users and 2960 units for the group of supervisors were fixed.

	Female users	Male users	Supervisors
O1[10]	2026	2865	2962
O2[11]	1790	2581	2892
Disagreement U	0,06	0,05	0,01
Agreement	93,82	94,79	98,80

TABLE 8 - GUETZKOW’S U CALCULATION DURING UNITIZING PROCESS

5.5. Categorization and coding

The category scheme was designed both deductively and inductively. The deductive categories were determined from preliminary surveys of Ge:MMaS as well as from literature and represents the basic category system.

This basic scheme can be divided into "hardware aspects" and "software aspects". The category system was developed based on the ergonomic and software ergonomic

[10] O1: Siegfried Sharma
[11] O2: Alfred Haidenbauer

requirements defined in ISO standards[12]. Thus there are 39 categories in the basic schema, which are shown in Table 9. The categories 11 to 17 and 30 to 37 represents preliminary investigations of Ge:MMaS.

	Hardware
1	Access to machines
2	Workplace dimensions
3	Seats
4	Physical stress , work intensity
5	Manually operated control devices
6	Keyboards , Keys and Input Devices
7	Display and indicators
8	Visual alarm signals
9	Integrated lighting equipment
10	Observation of the production process
11	No problems
12	Others
13	Emissions
14	Cleaning / Maintenance
15	Material loading
16	Material unloading
17	Focus
	Software
18	Design of software dialogue
19	Functional criteria
20	I/O criteria
21	Software dialogue techniques
22	Representation of visual information
23	Organization of the information
24	Multiple contexts
25	Operational safety
26	Directness
27	Inclusiveness
28	Naturalness
29	Intuitiveness
30	1 no problem
31	2 Preview
32	4 unstable, crashes
33	5 serial control
34	7 Creating graphics with ULS easier
35	Automatic parameter transfer
36	Setting the / software parameters
37	Interruption during the job
38	11 user friendliness
39	10 other

TABLE 9 - BASIC CATEGORIZATION SCHEMA

[12] ISO standards for hardware-requirements: DIN EN 1005, DIN EN 1837, DIN EN 547, DIN EN 60 204, VDE 0113 Part 1, DIN EN 61310; ISO standards for software-requirements: DIN EN ISO 9241

By using this deductive basic schema for first level coding, a lot of missing categories were found. Therefore, the deductive schema was extended with an additional inductive category schema, for units of analysis that could not be assigned to the basic categories. By content structuring, partial paraphrase and summary new categories were formed. As result, 32 new categories were added to the final category schema. The following tables (Table 10, Table 11 & Table 12) shows the final category schema, which was divided into three parts: works system elements, hardware and software[13].

Field	#	Category	
	1	Moderation	
	2	Demographics	
	3	Machine type	
	4	Purchase reasons	
breaking-in	5	Breaking-in system use general	
system use	6	Background experience	
	7	Manual requirements	
	8	Training requirements	
	9	Important to learn	
	10	Work requirements	
	11	Type of enrollment	
	12	Who gets which training	
	13	Learning by Doing / Trial & Error	
work system	14	Work system general	
	15	Laser system overall	INDUCTIVE
	16	Division of labor	
	17	Technical demand of materials	
	18	Co-decision ability in processing order	
	19	Variety at work	
	20	Good feeling at work	
	21	Stressful feeling at work	
	22	Exhausting situations	
	23	Cause of errors / rejects	
	24	Problem solving	
	25	Field of application	
	26	Material handling	
	27	Data management	
	28	Competitors systems	
	29	Trotec marketing	
	30	Accessories	
	31	Others - general	
	32	Discussion framework conditions	

TABLE 10 - FINAL CATEGORY SCHEMA WORK SYSTEM ELEMENTS

[13] Appendix B contains the original categorization schema in German language

Field	#	Category	
	33	Access to machines	DEDUCTIVE from literature
	34	Workplace dimensions	
	35	Seats	
	36	Physical stress , work intensity	
	37	Manually operated control devices	
	38	Keyboards , Keys and Input Devices	
	39	Display and indicators	
	40	Visual alarm signals	
	41	Integrated lighting equipment	
	42	Observation of the production process	
	43	No problems	DEDUCTIVE from preliminary investigations
	44	Emissions	
	45	Cleaning / Maintenance	
	46	Material loading	
	47	Material unloading	
	48	Focus	
	49	Others	

TABLE 11 - FINAL CATEGORIZATION SCHEMA – HARDWARE

Field	#	Category	
	50	Design of software dialogue	DEDUCTIVE from literature
	51	Functional criteria	
	52	I/O criteria	
	53	Software dialogue techniques	
	54	Representation of visual information	
	55	Organization of the information	
	56	Multiple contexts	
	57	Operational safety	
	58	Directness	
	59	Inclusiveness	
	60	Naturalness	
	61	Intuitiveness	
	62	No problem	DEDUCTIVE from preliminary investigations
	63	Preview	
	64	Unstable, crashes	
	65	Serial control	
	66	Creating graphics with ULS easier	
	67	Automatic parameter transfer	
	68	Setting the / software parameters	
	69	Interruption during the job	
	70	User friendliness	
	71	Other	

TABLE 12 - FINAL CATEGORIZATION SCHEMA - SOFTWARE

The whole process of build categories and coding war performed by both investigators. As quality criteria an intercoder matrix was built and Cohens κ was calculated (compare with

chapter 4.6.2). As already mentioned in this work, a value bigger than 0.75 represents a very good result. Too reach the best evaluation as possible, the aim in this project was a value of 0.8. Because of the good preparation including clear coding rules, this threshold value was reached in the first coding round, shown in Table 13. A simplified example how Cohens κ was calculated is shown in Figure 18, whereby several categories are removed for better legibility. [14]Based on the formula in chapter 4.6.2,

$$\kappa = (p_0 - p_c) / (1 - p_c)$$

$$p_0 = \Sigma\ Pii,\ p_c = \Sigma\ Pi \times Pi.$$

	female	male	supervisors
N	2139	3025	2975
p0	0,8279	0,8291	0,8114
pc	0,0856	0,1205	0,0734
Cohens K	0,8118	0,8057	0,7964

TABLE 13 - RESULTS OF COHENS KAPPA

[14] For all coding data please ask at the Department of Labour Science and Organization at the Institute of Management Science of the Vienna University of Technology or at the author

	AHa →													
SSh ↓	Category	1	2	3	4	5	6	7	8	9	10	70	71	Total
	1	84	0	0	0	0	0	0	0	0	0	0	0	87
	2	0	8	0	0	0	0	0	0	0	0	0	0	8
	3	0	0	3	0	0	0	0	0	0	0	0	0	3
	4	0	0	0	37	0	0	0	0	0	0	0	0	40
	5	1	0	0	0	89	0	0	0	0	0	0	0	121
	6	0	2	0	0	0	1	0	0	0	1	0	0	7
	7	0	0	0	0	0	0	20	0	0	0	0	0	20
	8	0	0	0	0	2	0	0	5	0	0	0	0	7
	9	0	0	0	0	23	0	0	0	6	0	0	0	39
	10	1	0	0	0	0	0	0	0	0	27	0	0	36
	70	0	0	0	0	0	0	0	0	0	0	116	0	116
	71	0	0	0	0	0	0	0	0	0	0	0	32	33
Total		126	10	3	37	180	1	20	6	6	36	116	33	2975

N	2975
p0	0,81142857
pc	0,0734277

kappa **0,79648493**

		126	10	3	37	180	1	20	6	6	36	116	33
1	87	10962											
2	8		80										
3	3			9									
4	40				1480								
5	121					21780							
6	7						7						
7	20							400					
8	7								42				
9	39									234			
10	36										1296		
70	116											13456	
71	33												1089

FIGURE 18 – EXAMPLE FOR CALCULATE COHENS KAPPA

5.6. Discussion of the results

Apart from the category schema, the sequences of mentioned topics, the frequency distributions of topics and the comparisons between the different user groups will be discussed and interpreted qualitative.

5.6.1. Relative frequencies by user groups

First, I want to analyse the relative frequencies of topics in each group, shown in Figure 19, Figure 20 and Figure 21. The main topics of the female group are “Field of application”, “Accessories” and “Functional Criteria”.

The initial statements, when Female users talked a lot about “Field of application”, were their products (see Table 14). Common products they mentioned are type labels, rubber stamps, signs and gravures on different materials like knifes, glasses or wood.

#	Code	P	Text
12	Field of application	BBl	*also wir machen Spielautomaten, Wettterminals, und wir verwenden eben den Laserdrucker eigentlich für die Typenschilder für unsere Geräte oder Modelle, was wir brauchen für Produktion. #00:04:09-5#*
17	Field of application	KKu	*Sie macht Stempel und ich mache so kleine Lasergravuren, wie Messer, auch Gläser und solche Sachen. #00:04:32-8# [[[EINIGUNG: es geht nur um das Anwendungsgebiet und nicht, wer welches Anwendungsgebiet hat => eine Unit bzw. Kategorie]]]*
24	Field of application	ALe	*und wir gravieren Schildern, Hausnummern, Stempel, viel für Tischlereien mit Holz und so. #00:05:02-8#*

TABLE 14 – FEMALE USERS: DISCUSSION ABOUT PRODUCT FIELDS

Another big issue are problems in the field of applications, especially problems with one-off productions. In that cases, they only have one chance to produce a good output, and there is no place for mistakes, what leads to fear and uncertainty. Table 15, as example, shows a conversations sample of this topic as representative for a long discussion about that.

#	Code	P	Text
145	Field of application	JMa	*habe aber panische Angst davor, dass es einmal einen Kunden gibt, der irgendwo mit einem Unikat kommt 'und da hätte ich jetzt gerne' und ich versaue es ihm. [[[&-Verknüpfung]]]*
146	Field of application	JMa	*[Gruppe nickt].*
147	Field of application	JMa:	*Da habe ich panische Angst davor. #00:16:34-5#*
148	Field of application	MMi:	*Das ist das Problem, mit den beigestellten Dingern, gell? Also #00:16:37-8#*
149	Field of application	JMa:	*Da gibt es nur eines, ich kann nicht probieren.*

TABLE 15 - FEMALE USERS: DISCUSSION ABOUT ONE-OFF PRODUCTIONS

Another interesting topic was the discussions about problems with special materials, especially glass and leather. Table 16 shows, that several participants have bad experiences when working with bottles and glasses.

#	Code	P	Text
381	Field of application	KKu	Unser Chef hat einmal eine Sektflasche gelasert. #00:32:33-5#
387	Field of application	JMa:	Die Lasern wir ja nicht.
388	Field of application	KKu, w:	Ja, ja
389	Field of application	JMa:	Weil die sind ja viel zu groß dafür.
390	Field of application	JMa	Ich glaube, so einen Laser gibt es gar nicht. Also der jetzt für uns auch #00:32:54-2#
391	Field of application	KKu:	Wobei, wir haben ab und zu so Glaskaraffen oder was weiß ich was. Ich finde das .. nicht, eignet sich nicht, für
392	Field of application	SSc:	Keine schöne Gravur

TABLE 16 - FEMALE USERS: DISCUSSION ABOUT GLASS

When the female group talked about "Accessories", their main focus was the pollution from emission of flue gas. They detected the extraction systems (when they are cutting, piece get stuck in the machine), carbon filters and rubber stamp as main problems in connection with the emissions. Especially the stench and the price of the carbon filters are a hot topic (see Table 17)

#	Code	P	Text
274	Accessories	MMi:	Erstens ist der Kohlefilter schweineteuer. [[[EINIGUNG REGEL18.1]]]
275	Accessories	MMi	Zweitens stinkt er {{{der Kohlefilter}}} furchtbar. [[[EINIGUNG REGEL18.1]]]
278	Accessories	MMi	weil den Kohlefilter braucht man auch nicht jedes Mal neu kaufen, [[[EINIGUNG Aussage]]]
279	Accessories	MMi	wir haben am Anfang einmal eine Reserve gekauft. [[[EINIGUNG Beschreibung wie gehandhabt wird]]]
280	Accessories	MMi	Und der Kohlefilter regeneriert sich in der Luft wieder. [[[EINIGUNG Begründung warum man Kohlefilter nicht jedesmal neu kaufen muss]]]

TABLE 17 - FEMALE USERS: DISCUSSION ABOUT CARBON FILTERS

An important topic at “Functional Criteria” is the usability of the software. It is possible to define forms for gravures in different colours, named colour management, to do different graving tasks in one job. Obviously, the software is not very operable instinctively and so, the output is often not the expected result (see Table 18).

#	Code	P	Text
985	Functional Criteria	JMa	Ich kenne das nur mit schwarz #00:58:05-6#
986	Functional Criteria	EMo, w:	Das müsste man austesten. #00:58:06-6#
987	Functional Criteria	JMa:	ist gravieren,
988	Functional Criteria	JMa	rot ist schneiden und dann war mir plötzlich, weil ich was plötzlich, ich habe nicht einfach nur, es ging mir nur darum, das auszuprobieren, da nehm ich aber was vorgegeben. Ist, und das war blau. [[[(1) Beispielhafte Erklärung für Problemnennung]]]
989	Functional Criteria	JMa	Da habe ich meinen Mann gefragt, was ist der Unterschied zwischen schwarz und blau?
990	Functional Criteria	JMa	Dann meinte er, also in dem Fall kannst du es eben einstellen [[[EINIGUNG beim Probieren]]]
991	Functional Criteria	JMa	und man kann das auch grün oder sonst was machen, [[[EINIGUNG Mann hat gesagt, man kann das mit irgendeiner Farbe machen kann]]]
992	Functional Criteria	JMa	aber wie gesagt, es geht immer nur darum, dass er in einem Arbeitsgang ja weiß, dass er Schwarz meinetwegen tiefer gravieren soll, oder einmal wie breit, was auch immer, was letztendlich Einstellung ist [[[EINIGUNG Beispiel für Erklärung unterhalb]]]

TABLE 18 - FEMALE USERS: DISCUSSION ABOUT SOFTWARE PROBLEMS

The main topics of the male participants are “Field of application”, “Training requirements” and “Learning by doing – Trial and Error”. When male users talk about “Field of application”,

they talk about their products on hand and try to find solutions for problems on the other hand. Table 19 shows typical products of male users, trophies, rubber stamps, panels for cars, glasses and all kind of individual wishes for customers.

#	Code	P	Text
44	Field of application	PPe	Hauptsächlich arbeiten wir oder produzieren wir Sporttrophäen, verkaufen selber Sporttrophäen, Stempel, für die Audioindustrie machen wir Paneele. Also wir arbeiten einfach ziemlich alles ab, was wir so in die Finger bekommen. [[[EINIGUNG gehört zusammen, weil „alles in die Finger bekommen“ zu Aufgabengebiet zählt]]]]
57	Field of application	RRi:	Glasgravuren, Plexischnitte, also eigentlich alles in Sachen Geschenke, Trophäen. Kundenwünsche nach frei Haus. #00:05:55-8#
96	Field of application	FKl	Wir machen nicht nur Stempel sondern auch, bearbeiten Acryl, wir bearbeiten Edelmetalle. Ich weiß gar nicht, wie das Material sich genau nennt, das ist so ein Edelstahlersatz. [[[EINIGUNG Anwendungsgebiet]]]]

TABLE 19 - MALE USERS: DISCUSSION ABOUT PRODUCTS

Generally, the male users tried to identify problems and exchange ideas and experiences about them and find solutions together. As example, Table 20 shows a discussion about one-off productions. Here, users recommended to work step by step, first to engrave very thin and later get thicker to get the wished result.

#	Code	P	Text
182	Field of application	FKl	*Und dann natürlich häufig auch vom Kunden angeliefertes Material, da hast du natürlich nicht viele Möglichkeiten, großartig auszuprobieren, entweder es klappt oder es klappt nicht. #00:13:23-1# [[[sagt aus, „dass bei vom Kunden angeliefertes Material nicht ausprobiert werden kann" + zus. REGEL11 (kann aber auch gehört zu „ Bei uns war das Problem, wir haben ständig wechselnde Sachen..]]]]*
183	Field of application	NNi:	*Mhm, {zustimmend}*
185	Field of application	HHo:	*Ja und du hast meistens nur einmal die Chance, nicht [Gruppe lacht] #00:13:29-3#*
186	Field of application	FKl:	*Eben, da überlegt man sich dreimal, wer wen jetzt an oder nicht.*
187	Field of application	RRi:	*Das Problem ist nur dann, wenn du da eine Steinplatte unter dir liegen hast, die vom Steinmetz her schon alleine auf 600 Euro kommt und dann sagst du dem, hmm, wurde leider nicht das, was wir wollten. #00:13:38-0#*
188	Field of application	FKl:	Wir haben mal das Problem, wir haben uns uns auch nur im auch nen Mont Blanc Füller, wenn der legt. Ich meine, das ist jetzt nicht das Problem, aber wenn du eben mal versäbelst, dann... #00:13:47-3#
189	Field of application	RRi:	[nickt {zustimmend}]
190	Field of application	HHo:	Ja, ja, ist schon klar. #00:13:48-8#
191	Field of application	NNi:	Wenns ein bereitgestelltes Material zum Beispiel ist, und a Schrift drauf kommt, da wäre es am Besten, dass man zum Beispiel das Schrift dünner macht und dann ausprobieren und nachher, wenn du siehst, das passt, dann dicker machen, also mit der Originalgröße und dann natürlich, hast du keinen Ausschuss. #00:14:08-9# [[[PROBLEMLÖSUNG verschiedene MATERIALIEN]]]]
192	Field of application	FKi:	[nickt]
194	Field of application	HHo:	Ja. Das ist aber bei diesen Sachen aber auch extrems feuchtig. Ich denke mir, da tu ich mich vorher einfach langsam einmal rantasten, gucken, dann voll reinhängen. #00:14:18-6# [[[PROBLEMLÖSUNG verschiedene MATERIALIEN]]]]

TABLE 20 - MALE USERS: DISCUSSION ABOUT ONE-OFF PRODUCTIONS

A remarkable dynamic inside the male group tried to develop a training concept, what includes a basic training at Trotec, away from the working place, to concentrate fully on the training, followed from a briefing on side, when Trotec installs the machine. At the end, after some months, there should be a service from Trotec for differently queries. Table 21 shows the summary of the requirements for the training.

	Code	P	Text
1618	Training requirements	FKl	man würde unterscheiden zwischen Grundschulung und, ich sag einmal, Weiterführungsschulung.
1618	Training requirements	FKl	man würde unterscheiden zwischen Grundschulung und, ich sag einmal, Weiterführungsschulung.
1619	Training requirements	FKl	Nein, dann sehe ich das auch so wirklich, die Grundschulung hier, {{{bei Troetec}}}
1620	Training requirements	FKl	einfach einmal auch vom Tagesgeschäft rausgenommen zu werden.
1621	Training requirements	FKl	Dann die Installation vor Ort. Dass man da dann noch zwei, drei klärende Worte, oder auch fünf gerne bekommt
1622	Training requirements	FKl	und dann würde ich auch nach ein bis zwei Monaten [[[EINIGUNG wann]]]
1623	Training requirements	FKl	wirklich noch einmal das einer raus kommt und sagt, so, das Material, was hast du denn da für Probleme,
1624	Training requirements	FKl	was hast du da für ein Problem,
1625	Training requirements	FKl	und dann gehe ich in der Firma explizit gucken, woran hängt das? #01:16:41-3#
2164	Training requirements	HHo	Und wie gesagt, vielleicht dann nach einem Monat oder eineinhalb Monate oder von mir aus zwei Monate, wo einer {{{von Trotec}}} dann herkommt und sagt, was gibt es für ein Problem?
2165	Training requirements	HHo	Oder hast du überhaupt keines,
2166	Training requirements	HHo	oder, ich sage ja, wir machen jetzt, wir wollen ja auch in Zukunft mehr Sachen machen,
2167	Training requirements	HHo	auch dort im Geschäft, wo der Kunde kommt und sagt, 'habe ich einen Flachmann, wo ich durchschauen kann auf der anderen Seite',
2168	Training requirements	HHo	nein, wo ich auch, so gewisse Kleinigkeiten [[[IEINIGUNG REGEL18.1]]]
2169	Training requirements	HHo	oder was weiß ich, Nirosta. [[[IEINIGUNG REGEL18.1]]]
2188	Training requirements	HHo	Nein, aber,
2189	Training requirements	HHo	und je mehr das in der Firma ist, umso gescheiter ist das. #01:37:45-0#

TABLE 21 - MALE USERS: DISCUSSION ABOUT TRAINING REQUIREMENTS

The male group describes, that the work on the machines always be a new challenge and really learning by doing, even same materials can behaves differently on time. To gain experience, various materials get tested and it is essential to make mistakes and learn from them. Gaining experience is, according to the male users, to reduce the fears working with the machine (see Table 22).

#	Code	P	Text
740	Learning by Doing/Trial & Error	NNi	Also früher habe ich mir nicht so zugetraut, die ganzen Einstellungen zu verändern und so. Habe ich mir nicht zugetraut. [[[EINIGUNG REGEL5]]]
741	Learning by Doing/Trial & Error	NNi	Habe ich mir gedacht, ich werde irgendwas beim Laser verhauen und so. [[[EINIGUNG Begründung warum kein Zutrauen zu sich selbst]]]
742	Learning by Doing/Trial & Error	NNi	Das ist ein wertvolles Gerät. [[[EINIGUNG Erklärung]]]
743	Learning by Doing/Trial & Error	NNi	Und ja, jetzt trau ich mir mehr zu. #00:42:26-2# [[[EINIGUNG Zutrauen in sich selbst ist gestiegen]]]
745	Learning by Doing/Trial & Error	NNi	Man hat sicher auch Erfahrung gesammelt. #00:42:28-1#
746	Learning by Doing/Trial & Error	FKl:	Da verhaust eins. Dann weißt, dass nicht geht. [Gruppe lacht]. #00:42:34-9#
748	Learning by Doing/Trial & Error	NNi:	Dann sagt dir der Chef noch mal, das geht so nicht. Irgendwann wirst du es auch begreifen. #00:42:42-8#
750	Learning by Doing/Trial & Error	FKl:	Wenn der Kopf unter der Schulter immer länger wird [Gruppe lacht], dann stimmt was nicht.
753	Learning by Doing/Trial & Error	RRi:	und dann auch einfach durchs probieren. #00:42:58-5# [[[EINIGUNG REGEL18.1]]]
773	Learning by Doing/Trial & Error	RRi	aber eben auch auf Grund auch dessen, von unserem Anwendungsbereich, wo wir arbeiten, [[[EINIGUNG Begründung, dass es bei ihnen sinn macht zu probieren, auf Grund ihres Anwendungsbereiches]]]
778	Learning by Doing/Trial & Error	RRi	wenn du Erfahrung sammeln willst, dann musst du das so machen. [[[EINIGUNG Begründung warum man trial & error machen muss]]]
779	Learning by Doing/Trial & Error	RRi	Dann musst du einfach dann gewisse Stunden Zeit {{{opfern}}} [[[EINGUNG Konsequenzen REGEL18.1]]]
780	Learning by Doing/Trial & Error	RRi	und {{{da musst Du}}} Material opfern. [[[EINIGUNG Konsquenzen REGEL18.1]]] #00:44:17-6#
1143	Learning by Doing/Trial & Error	FKl	Und so auch aus diesen Versuchen heraus wieder Ideen [[[EINIGUNG aus Veruschen entsthen Ideen -- Innovationspotential]]]
1444	Learning by Doing/Trial & Error	RRi	und und und und da wieder {{{die Ideen, die aus diesen Versuchen entstanden sind}}} ausprobiert.

TABLE 22 - MALE USERS: DISCUSSION ABOUT LEARNING BY DOING/TRIAL & ERROR

The main topics of the supervisors are “Field of application” and “Accessories”. The group of supervisors also had various fields of applications as main topic, with a big focus on solution-orientation and calculation of prices for individual products. Table 23 shows a discussion about the problem with engraving photos, that there are often several tries necessary to reach a good result and that it is important to calculate this aspects in the end price.

#	Code	P	Text
1295	Field of Application	KSi, rw:	Wie oft braucht ihr, bis ein Foto wirklich gut ausschaut? [OKo lacht {gute Frage}, JAu + EHa, lachen].
1297	Field of Application	TTi:	Das ist ein Erfahrungswert. [lacht, alle lachen].
1298	Field of Application	OKo:	Das ist wirklich gut (.so wie) {gesagt}
1299	Field of Application	EHa:	Also,
1300	Field of Application	KSi:	Ich mein, oder, oder wie macht ihr halt das, um, um, am effizientesten?
1301	Field of Application	EHa, wd:	Also ich habe einmal eine riesen Platte gemacht.
1302	Field of Application	OKo:	[nickt]
1303	Field of Application	CSp:	[macht Noitzen]
1304	Field of Application	TTi:	Das ist eine Überraschung
1305	Field of Application	EHa, wd:	Hingeschrieben, mit wie viel dpa ich das mache und,
1306	Field of Application	OKo:	[nickt, lacht {das kenn ich?}]
1307	Field of Application	EHa, rw:	und es funktioniert auch nicht, jedes Bild ist anders, das ist,
1308	Field of Application	KSi, wd:	Hmh
1309	Field of Application	EHa, rw:	zum verrückt werden, also.
1310	Field of Application	KSi:	Und wie geht ihr an das Problem her? Oder wie, genau?
1311	Field of Application	OKo:	[lacht, schütttelt Kopf {keine Ahnung wie}] Probierern [lacht]
1312	Field of Application	KSi:	Ja, das is eh des {was ich auch mache} [zu OKo]
1313	Field of Application	EHa, gl:	Den offerierten Preis, den offferierten Preis sehr gut rechnen, [lächelt; OKo, TTi, KSi lachen]
1314	Field of Application	JAu:	Ja [lacht]
1315	Field of Application	EHA, rw:	weil man macht das eben zwei-, dreimal, also
1316	Field of Application	CSp:	Ja [macht Notizen, lächelt]
1317	Field of Application	JAu:	Das kommt auf das Material drauf an,
1318	Field of Application	KSi, wd:	Ja
1319	Field of Application	JAu:	und das geht genau so auch nur ned [schütttelt den Kopf]

TABLE 23 - SUPERVISORS: DISCUSSION ABOUT "FIELD OF APPLICATION"

Supervisors also know problems with extraction systems, but they were more interested in talking what accessories are necessary to work efficient. At the moment, their workers have to improvise a lot, and they want to stop this with suitable accessories. Another big subject was cutting acrylic, that there are some problems and that the material loading process is not optimal for this work. (see Table 24)

#	Code	P	Text
2294	Accessories	EHa, rw:	und diese, diese zwei Türme, oder.
2295	Accessories	EHa	Und die filtern schon (..) und sonst
2305	Accessories	EHa	Merkt man das ja nicht direkt, {{{{wenn zum Beispiel irgendeine Filterstufe, ein Loch hat}}}}
2306	Accessories	CSp:	Hmh unter Umständen, oder. {{{{{Merkt man das ja, wenn zum Beispiel irgendeine Filterstufe, ein Loch hat}}}}
2307	Accessories	EHa, wd:	Hmh
2308	Accessories	BBi, rw:	Und dann hat man den ganzen Dreck im Zimmer drinnen. {{{{wenn Filterstufe ein Loch hat um Beispiel}}}}
484	Accessories	CSp:	und lege mir das rein, und habe dann meine Acryl {oben drauf} [stellt mit den Händen Inhalte dar]
492	Accessories	BBi:	Ja gut, ich lege eben Holzzahnstocher drunter,
493	Accessories	BBi	irgendwie so was [[[wie einen Holzzahnstocher]]], quer drunter legen, fertig.
497	Accessories	BBi:	Ja.
499	Accessories	JAu:	Ja inzwischen habe ich schon einen ganzen Stapel Vorlagen neben her [deutet Stapel an]. [lacht und OKo, BBi, CBö. CSp dürfte lächeln].
501	Accessories	TTi:	Ein Bekannter von mir, der macht -- ich weiß nicht, was er für einen Laser hat, das ist ein ganz anderer Hersteller -- und der hat sich für so Serienfertigung -- all so was --, hat er sich eine große Legoplatte unten rein gelegt

TABLE 24 - SUPERVISORS: DISCUSSION ABOUT "ACCESSORIES"

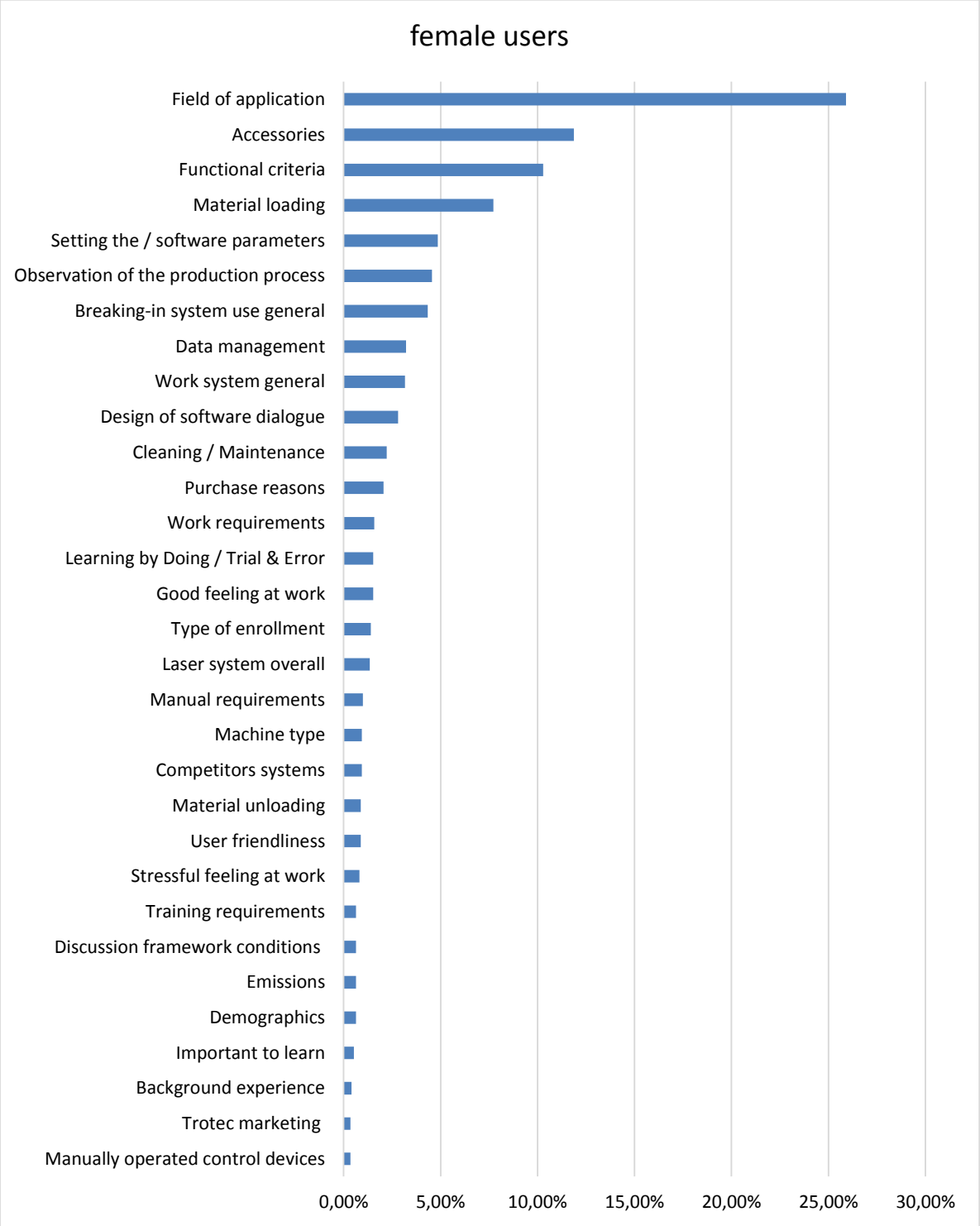

FIGURE 19 - FEMALE USERS – RELATIVE FREQUENCIES

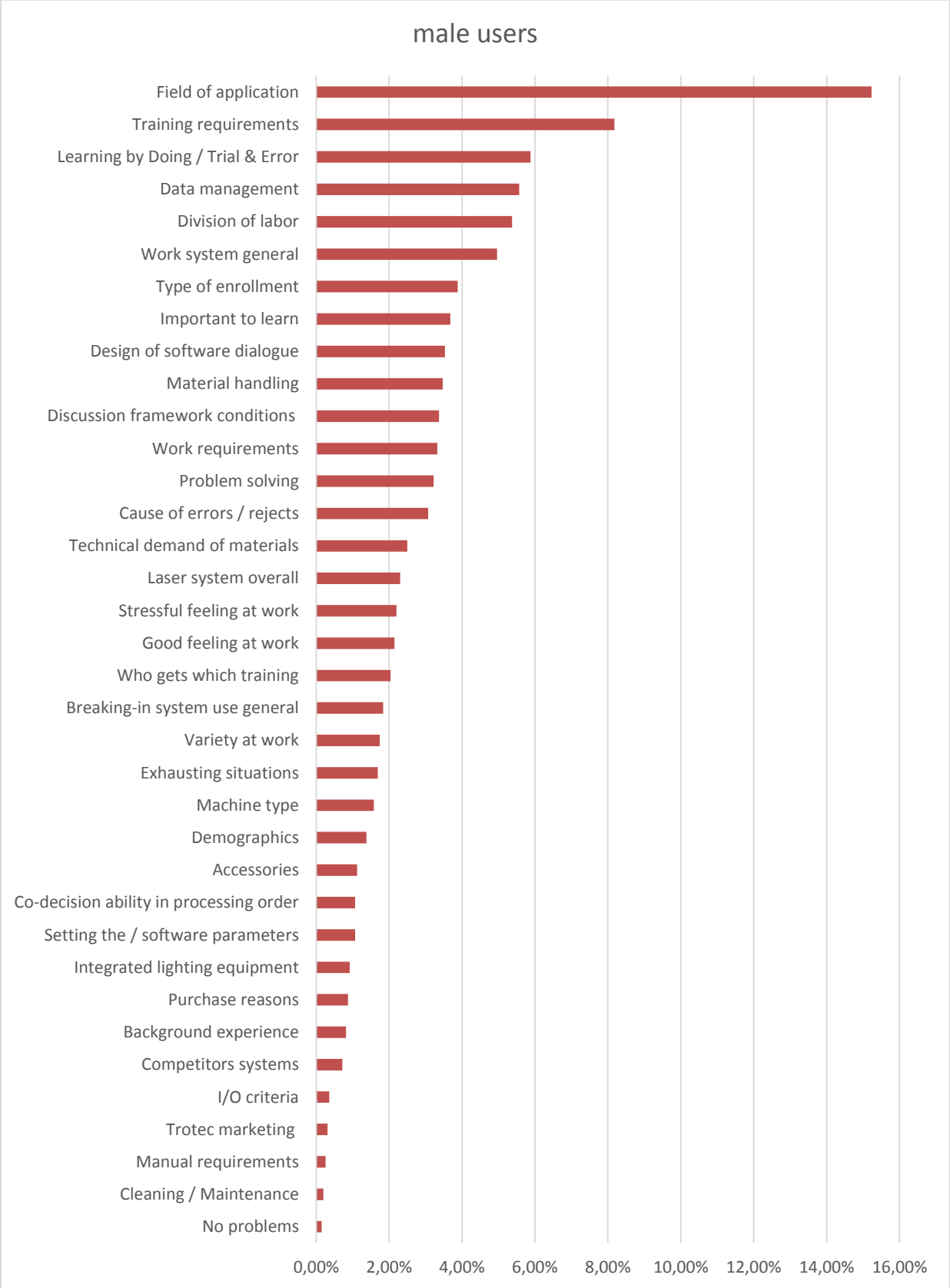

FIGURE 20 – MALE USERS – RELATIVE FREQUENCIES

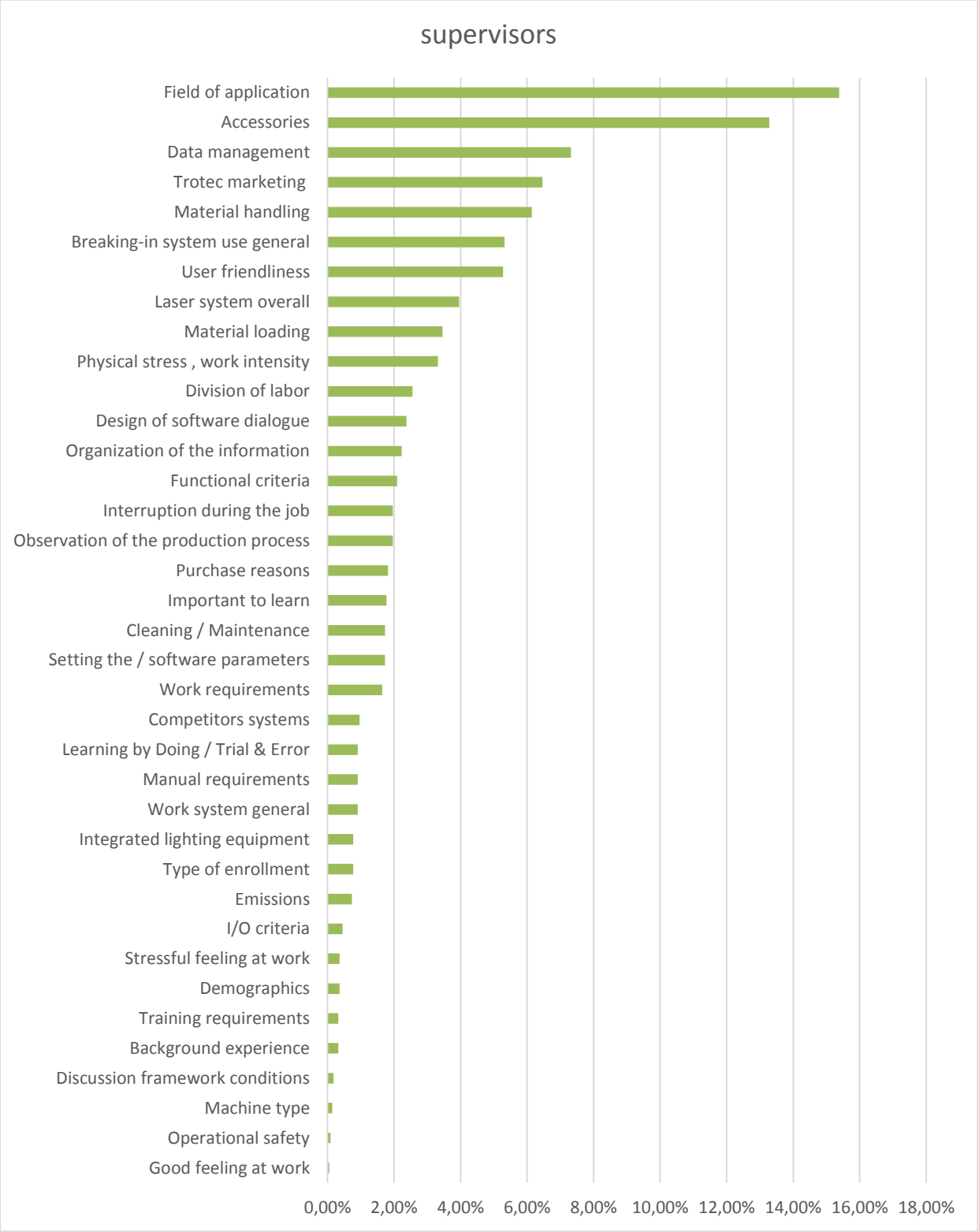

FIGURE 21 – SUPERVISORS – RELATIVE FREQUENCIES

5.6.2. Sequences of topics

The sequences of topics is an important and interesting issue when considering the hypothesis that participants not only repeat their most relevant subjects, they also bring them up earlier than other subjects. So the first topic should be considered especially. For this analysis, the data were clustered in blocks of 100 units and main issue in each block was found. The result is shown in Table 25.

female	Male	supervisors
Accessories	Learning by Doing/Trial & Error	Accessories
Field of application	Field of application	User friendliness
Accessories	Field of application	Laser system overall
Field of application	Data management	Accessories
Cleaning / Maintenance	Material handling	Interruption during the job
Accessories	Material handling	Observation of the production process
Accessories	Field of application	User friendliness
Breaking-in system use general	Cause of errors / rejects	Accessories
Functional criteria	Type of enrollment	Laser system overall
Functional criteria	Training requirements	Laser system overall
Field of application	Training requirements	Field of application
Design of software dialogue	Design of software dialogue	Breaking-in system use general
Setting the / software parameters	Division of labor	Field of application
Observation of the production process	Work system general	Physical stress , work intensity
Field of application	Work system general	Material handling
Field of application	Work requirements	Data management
Field of application	Division of labor	Breaking-in system use general
Field of application	Good feeling at work	Work system general
	Stressful feeling at work	Field of application
	Problem solving	Division of labor
		Organization of the information
		Setting the / software parameters
		Data management

TABLE 25 - TOPIC SEQUENCE

According to the relative frequencies, the main topics of the female users are “Field of application” and “Accessories”. “Accessories” was the first issue this group discussed, but with the time, “Field of application” gain the upper hand.

When we take a look on the male users, we see balanced ratio between the different topics, with a light majority of “Field of applications”. That is an indicate that the male users tried to exchange as many experiences as possible in the time they had. “Learning by Doing/Trial & Error”, as first mentioned topic in this analysis, has also a special value for this user group.

The analysis of the supervisors shows, that “Field of application” and “Accessories” also top-topics for this group. Additional to these two topics, “Laser system overall” is a topic with high attention.

5.6.3. Comparison of user groups

According to the relative frequencies of all user groups, the most relevant topic was “Field of application” (h_{female} = 25.9%, h_{male} = 15.23%, $h_{supervisors}$ = 15.38%). Other “big” subjects are “Data management” (h_{female} = 3.22%, h_{male} = 5.57%, $h_{supervisors}$ = 7.32%) and “Accessories” (h_{female} = 11.87%, h_{male} = 1.12%, $h_{supervisors}$ = 13.28%).

Figure 22 shows the comparison of the different frequencies between the user groups over all topics. The big agreement between all groups is “Field of application”, whereby the content is different between the single groups. As mentioned in 5.6.1, female users mainly talk about problems and their fear of making mistakes. Only for single problem solution were found. Very different is the content of the male und supervisor groups. The focus of this groups was to find solutions for certain problems single participants had a long time.

“Accessories” were an important topic for females and supervisors. Especially extraction systems were interesting for both. For the male users, accessories are only a side issue.

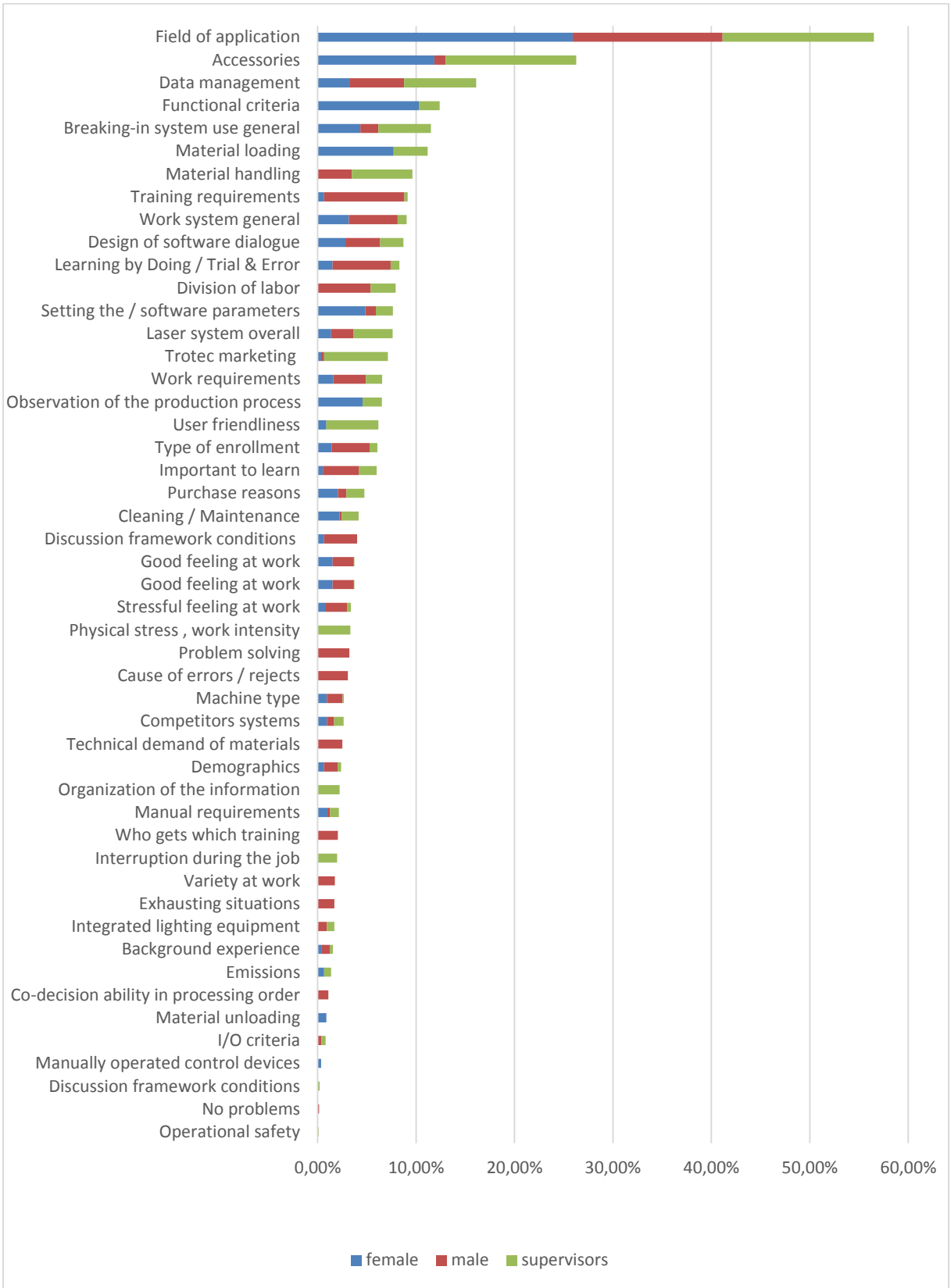

FIGURE 22 - COMPARISON BETWEEN USER GROUPS

As a relevant issue in the female group, functional criteria was also showed up. Supervisors gave that subject of minor importance, the male users didn't talked about it. As already mentioned, the female group discussed the complexity of the, engraving and cutting necessary, colour settings. The supervisors criticised problem after software updates, especially the availability of the program after them.

"Material loading" was only topic in the group of females and supervisors. While females talked about improvisation, how they fixed different materials, like with magnets or tape, supervisors talked about some problems with acrylic, and that there is no suitable inlay available.
The male group tried to develop a training concept, what includes a basic training at Trotec up to later service. In the other discussion groups, the request to trainings was very small. However, the general breaking-in of the system use was relevant, especially external security audits were thematised. The group of women talked almost about seminars for laser safety enrolment, because they got hints by the AUVA[15] to do that kind of seminars. The group of supervisors also discussed the security seminars, in detail the possibility to train staff to radiation protection officer.
Another subject here was to "best practise examples" for the daily work with the laser system. The group found two solutions: a newsletter or a restricted online area, where Trotec provides this information.

Another interesting subject, even its frequency was not very high, was "learning by doing / trial and error". Especially the male group saw a great importance in this issue. The male group describes, that the work on the machines always be a new challenge and really learning by doing, even same materials can behaves differently on time. To gain experience, various materials get tested and it is essential to make mistakes and learn from them. This approach could be an indicator, why the male groups has, in comparison to with the female group, less

[15] AUVA: Allgemeine Unfallversicherungsanstalt, german for General Accident Insurance Institution

problems in the field of applications. As additional input, supervisors suggested it would be a great idea to develop an exchange platform for experiences with Trotec laser systems.

6. Conclusion

The initial hypothesis of this work was, that there are differences in the requirements of different user groups when working with Trotec laser systems. The additional research question was, whether the used research method is suitable for evaluating that requirements.

Based on Focus group held in three groups – female, male and supervisors – a content analysis method, with the aim of collecting content relevant systems, as well as frequencies of the mentions, was processed. In the evaluation the steps unitizing, coding, categorization as well as the final analysis was applied. As units for step one, units of meaning were chosen, because they are suitable to deliver the best details to answer the research questions. The categorization was done deductive and inductive. The deductive category system was formed from the previous surveys of the project as well as from literature. The inductive system was carried out from the transcripts of the Focus Groups. For all these processes, two investigators were used to ensure an appropriate quality of the results.
The analysis delivered some accordance as well as many differences in the requirements between the user groups, especially between females and males. The whole evaluation process took a lot of human resources, but at all it was a suitable method to determine user requirements.

In detail, the field of applications with Trotec laser systems is the most relevant topic for all kind of users. Contextual, there are some differences. Female users presented uncertainties in the usage of the machines, especially when working with unique items. It is noticeable that there is a big demand for better support how to work with different materials.
Male users exposed themselves as solution-oriented and interested in experience exchange. They discussed different problems, and also found suitable solution for some of them. A similar behaviour was seen at the supervisors group. A particle platform for knowledge exchange is a logical solution.

The methodical approach of Ge:MMaS is a triangulation of different common approaches – a content, discourse and function analysis as soon as Focus Groups and Participatory Workshops. The aim is to determine demand profiles for industrial machines. This new approach offers a new basis for future developments as well as future researches.

The practical implications are already reality. Trotec's newest representative of the Speedy product line – the Speedy 400 – was developed with a special focus on usability with the first results of Ge:MMaS. One improvement of Speedy 400 is a remote control of the laser via App.

From today's perspective the proposed approach seems be practicable for industrial machines and according software. The trend is going more and more in that way. The approaches in that work, respectively from Ge:MMaS, providing a workable basis for that, because of the flexible integration in the existing development processes. Furthermore, it provides all to find the requirements of the "real" end-users, widely more than previous methods.

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8. List of Figures

9. List of Tables

10. Appendix

A. Ge:MMaS project reports

Haidenbauer, A./Sharma, S./Filzmoser, M. and Koeszegi, S.: Zwischenbericht der Ge:MMaS -- Unitizing; 2013

Sharma, S./Haidenbauer, A./Filzmoser, M. and Koeszegi, S.: Bericht zu Ge:MMaS – Gruppendiskussionen; 2013

Sharma, S.: Methoden zur Ermittlung diverser Anforderungen; 2013

B. Categorization schema (English and German versions)

Final categorization schema in English:

#	Category	Detailed rule
1	Moderation	
2	Demographics	
3	Machine type	
4	Purchase reasons	
5	Breaking-in system use general	All units, which refers to aspects to the general breaking in the system use. This not includes Training requirements or the Type of enrolment. Aspects of learning after the initial training are included here.
6	Background experience	All kind of background experience with the work itself and machines. All kind of demographical issues are not included here.
7	Manual requirements	
8	Training requirements	Training requirements for training events!
9	Important to learn	More detailed that Category 5, asks more for the fundamental aspect and key determinants. No general aspects (they are in Category 5)
10	Work requirements	

11	Type of enrollment	How do the enrollments look like, how is the role of supervisors and workers?
12	Who gets which training	
13	Learning by Doing / Trial & Error	
14	Work system general	Includes the work environment (social, physical, physically). Also the way of working and similar aspects.
15	Laser system overall	All aspects refers to the whole laser system, like grading of it.
16	Division of labor	
17	Technical demand of materials	
18	Co-decision ability in processing order	
19	Variety at work	
20	Good feeling at work	When do you have a good feeling at work?
21	Stressful feeling at work	When is work stressfully?
22	Exhausting situations	What are exhausting situations at work?
23	Cause of errors / rejects	All reasons for errors and rejects (like Unit 57 at the Female Group). This reasons can be divided into technical and human issues.
24	Problem solving	How do you solve problems, or how do arrange with them?
25	Field of application	All units to different application fields, different materials (but not different manufacturers in one material group)
26	Material handling	This category refers to the material itself (for example which manufacturers of different materials are the best), also the storage of them.
27	Data management	All aspects of system configurations, parameters of the Trotec software.
28	Competitors systems	

29	Trotec marketing	
30	Accessories	Statements which refers to accessories to the machines. That can be official accessories, but also individual solutions of the workers.
31	Others - general	Other statements, which cannot assigned to a category and don't refers to soft- or hardware
32	Discussion framework conditions	All aspects which have impact to the discussion.
33	Access to machines	All statements which refers to the access to the machine and the place where the machine is (for cleaning, working, maintenance,…)
34	Workplace dimensions	
35	Seats	
36	Physical stress , work intensity	
37	Manually operated control devices	
38	Keyboards , Keys and Input Devices	
39	Display and indicators	Not the content of the display, here is thevisualisation important (Layout, luminosity).
40	Visual alarm signals	
41	Integrated lighting equipment	
42	Observation of the production process	
43	No problems	
44	Emissions	

45	Cleaning / Maintenance	The cleaning and maintenance of the machine itself and the official accessories.
46	Material loading	
47	Material unloading	
48	Focus	
49	Others	
50	Design of software dialogue	
51	Functional criteria	
52	I/O criteria	
53	Software dialogue techniques	
54	Representation of visual information	
55	Organization of the information	
56	Multiple contexts	
57	Operational safety	
58	Directness	
59	Inclusiveness	
60	Naturalness	
61	Intuitiveness	
62	No problem	
63	Preview	
64	Unstable, crashes	
65	Serial control	
66	Creating graphics with ULS easier	
67	Automatic parameter transfer	
68	Setting the / software parameters	
69	Interruption during the job	
70	User friendliness	
71	Other	

Final categorization schema in German language:

#	Kategorie	Regelwerk detailliert
1	Moderation	
2	Demographische Daten	
3	Maschinentyp	
4	Anschaffungsgründe	
5	Anlernen der Systembenutzung Generell	Hierzu zählen Units, welche generelle Aspekte der Systemanlernung ansprechen, wobei Anlernen der Systembenutzung klar von Schulung zu trennen ist, weil letztere sich auf die initiale (Grund-) Ausbildung beziehen. Das Anlernen der Systembenutzung umfasst auch jene Lernaspekte die nach dieser initialen Ausbildung erfolgen.
6	Erfahrungshintergrund	Erfahrungshintergrund zeigt Erfahrung mit der Arbeit und dem Arbeitsgerät auf und ist klar von demographischen Daten abzugrenzen (weil sich diese lediglich auf personenbezogene Daten wie Alter, Herkunftsland, etc. beziehen)
7	Handbuch Anforderung	
8	Schulung Anforderung	Schulung ist immer eine Veranstaltung
9	Wichtig zum Lernen	Unterscheidet sich von Anlernen der Systembenutzung generell. Geht mehr in die Tiefe, fragt nach den Fundamentalen Aspekten, den Key-Determinanten. Wohingegen Anlernen der Systembenutzung ebenfalls allgemeine Aspekte erfasst.
10	Voraussetzung für die Arbeit	
11	Art der Einschulung	Diese Kategorie gibt Auskunft darüber, wie die User des Systems für die Bedienung der Maschinen angelernt wurden, sowie Vorgesetzten Ihre MitarbeiterInnen einschulen (möchten). Auch Konsequenzen,

		Erklärungen, Begründungen, Beispiele, die Kern dieser Thematik darstellen, werden dieser Kategorie hinzugezählt.
12	Zusammenhang wer wie eingeschult wird	
13	Learning by Doing/Trial & Error	
14	Arbeitssystem Generell	Betrifft die Arbeitsumgebung (sozial, physisch, physikalisch, usw.) in dem die Arbeit durchgeführt wird sowie Arbeitsweise oder ähnliche Aspekte.
15	Laser-Gesamtsystem	In dieser Kategorie werden Aspekte die das gesamte Lasersystem ansprechen erfasst, wie beispielsweise auch Bewertungen zum Gesamtsystem.
16	Arbeitsteilung	
17	Technischer Anspruch von Werkstoffen	
18	Mitentscheidungsfähigkeit bei der Bearbeitungsreihenfolge	
19	Abwechslung bei der Arbeit	
20	Gutes Gefühl bei der Arbeit	Wann haben Sie ein gutes Gefühl bei der Arbeit?
21	Stressiges Gefühl bei der Arbeit	Wann wird die Arbeit an der Maschine stressig?
22	Anstrengende Situationen	Welche Situationen sind richtig anstrengend?
23	Ursache für Fehler / Ausschuss	Zeigt Gründe auf, die für Ausschüsse bzw. Fehler verantwortlich sind, wie beispielsweise bei Unit 57 bei Gruppe Grün. Gründe für Ausschuss/Fehler können primär in der Maschine und den MaschinenbedienerInnen unterteilt werden.

24	Problembewältigung	Gibt an wie die User Probleme im Arbeitsalltag (wie im Arbeitsprozess) lösen, wenn diese nicht Learning by Doing praktizieren. Hierzu zählt beispielsweise die Kontaktaufnahme mit dem Hersteller der Lasersysteme (Trotec). Achtung, Improvisationstechniken werden zu Learning by Doing gezählt, weil es sich dabei immer um iterative Anpassungen handelt, wohingegen Kontaktaufnahme zu Trotec nicht zu Learning by Doing gezählt werden kann.
25	Anwendungsgebiet	Betrifft Aussagen zu unterschiedlichen Anwendungsgebieten (Serienfertigung, Einzelfertigung, Stempel, Gravur, usw.), unterschiedlichen Materialien (aber nicht unterschiedlicher Hersteller innerhalb derselben Materialgruppe)
26	Materialhandhabung	Betrifft den Bezug des Materials (z.B. welcher Hersteller innerhalb einer Materialgruppe wie beispielsweise bei Stempelgummi, welcher Lieferant), bzw. die Lagerung (Versorgung) der Materialien in den Unternehmen, VT und Nachteile der einzelnen Herstellerprodukte (in Preis, Qualität, Emissionen, Ergebnis, usw.). Betrifft Aussagen zu gleichen Materialgruppen verschiedener Hersteller.
27	Datenmanagement	Betrifft das Abspeichern der Systemeinstellungen und Parameter nur der Software sowie Systemdaten die von Trotec zur Verfügung gestellt werden (zu unterscheiden von Informationsmanagement)
28	Konkurrenzsysteme	

29	Marketing Trotec	
30	Zubehör	Betrifft Aussagen (z.B. Probleme) zum Zubehör an den Maschinen. Zubehör sind beispielsweise Linsen, Filteranlagen, usw. die durch Trotec zur Verfügung gestellt oder von den TeilnehmerInnen selbst gefertigt und/oder benötigt werden (keine Materialien)
31	Sonstiges-Allgemein	Thementrennung, wenn sonstiges, dass über Hardware und Software steht, bzw. keinem von beiden zugeordnet werden kann+
32	Rahmenbedingung Diskussion	Parameter die Einfluss auf den Diskussionsverlauf haben oder darüber Aufschluss geben (z.B. Nachfragen, wenn akustisch nicht verstanden wird, wenn ein mitgebrachtes Material hergezeigt werden möchte, wenn ein Arbeitskollege nicht bei Gruppendiskussion ist und von Diskussionsteilnehmer angesprochen wird, dass diese(r) das jetzt erklären könnte)
33	Zugang zu Maschinen	In dieser Kategorie werden Aussagen zur Zugänglichkeit in die einzelne Bereiche der Maschine (hinein) erfasst, die für den Arbeitsablauf, Reinigung, Wartung bzw. im Arbeitsalltag mit den Maschinen erforderlich ist, wie beispielsweise der Zugang zum Arbeitsraum der Maschine. Eine Zugangsöffnung stellt dabei eine Öffnung dar, "die einer Person das Hineinlehnen, Hineinreichen oder Hineinstecken von Oberkörper, Kopf, Arm, Hand, eines oder mehrerer Finger, von Bein oder Fuß ermöglicht, um Maßnahmen im

		Rahmen von Arbeitsabläufen, wie das Betätigen von Stellteilen, Instandhaltungsaufgaben oder das Beobachten von Vorgängen oder Anzeigen, durchzuführen." Mindestgröße von Ganzkörperzugängen an Maschinenarbeitsplätzen Mindestmaße von Zugangsöffnungen
34	Arbeitsplatzmaße	
35	Sitze	
36	Physische Belastung, Arbeitsschwere	
37	Handbediente Stellteile	
38	Tastaturen, Tasten und Eingabegeräte	
39	Display und Anzeigen	Hier geht es nicht um den Inhalt des Displays sondern um die Darstellung der Informationen aus geeigneter Perspektive, mit entsprechender Leuchtkraft usw.
40	Optische Gefahrensignale	Hierbei handelt es sich um Warn- und/oder Gefahrensignale der Maschine
41	Maschinenintegrierte Beleuchtung	
42	Beobachtung des Arbeitszyklus im Fertigungsprozess	
43	keine Probleme	
44	Emissionen	
45	Reinigung / Wartung	Betrifft Reinigung/Wartung der Trotec-Systeme bzw. der Zubehör
46	Materialbeladen	
47	Materialentladen	
48	Fokussierung	
49	Sonstiges	
50	Software-Dialoggestaltung	

51	Funktionale Kriterien	
52	Kriterien Ein/Ausgabe	
53	Software-Dialogtechniken	
54	Darstellung visueller Informationen	
55	Organisation der Informationen	
56	Multiple Kontexte	
57	Bediensicherheit	
58	Direktheit	
59	Einbezogenheit	
60	Natürlichkeit	
61	Intuitivität	
62	kein Problem	
63	Vorschau	
64	instabil, stürzt ab	
65	serielle Ansteuerung	
66	Erstellen von Grafiken bei ULS einfacher	
67	Automatische Parameterübernahme	
68	Einstellung der Parameter / Software	
69	Unterbrechung während des Jobs	
70	Bedienerfreundlichkeit	
71	sonstige	

C. *Cohen's kappa calculations*

SSh ↓	AHa → Kategorie	1	2	3	4	5	6	7	8	9	10	70	71	Randhäufigkeit
	1	127	0	0	0	0	0	0	0	0	0	0	0	128
	2	0	11	0	0	0	1	0	0	0	0	0	0	21
	3	0	0	28	0	0	0	0	0	0	0	0	0	31
	4	0	0	0	15	0	0	0	0	0	0	0	0	15
	5	0	0	0	0	1	0	0	30	0	0	0	0	36
	6	0	0	0	0	0	1	0	0	0	0	0	0	3
	7	0	0	0	0	0	0	4	0	0	0	0	0	7
	8	1	0	0	0	0	0	0	150	18	0	0	0	183
	9	0	0	0	0	0	0	0	0	39	0	0	0	55
	10	0	0	0	0	0	0	0	0	0	58	0	0	64
	70	0	0	0	0	0	0	0	0	0	0	0	0	0
	71	0	0	0	0	0	0	0	0	0	0	0	21	21
Randhäufigkeit		131	18	30	19	1	13	5	203	61	85	3	26	3025 / 3025

N	3025
p0	0,82909091
pc	0,12053854
kappa	**0,8056662**

		131	18	30	19	1	13	5	203	61	85	3	26
1	128	16768											
2	21		378										
3	31			930									
4	15				285								
5	36					36							
6	3						39						
7	7							35					
8	183								37149				
9	55									3355			
10	64										5440		
70	0											0	
71	21												546

	AHa →													
SSh ↓	Kategorie	1	2	3	4	5	6	7	8	9	10	70	71	Randhäufigkeit
	1	20	0	0	0	0	0	0	0	0	0	0	0	20
	2	0	10	0	0	0	0	0	0	0	0	0	0	10
	3	0	0	15	0	0	0	0	0	0	0	0	0	15
	4	0	0	0	22	0	0	0	0	0	0	0	0	24
	5	0	0	0	0	71	0	1	0	0	0	0	0	79
	6	0	1	0	0	0	7	0	0	0	0	0	0	19
	7	0	0	0	0	3	0	16	0	0	0	0	0	19
	8	0	0	0	0	0	0	0	11	0	0	0	0	11
	9	0	0	0	0	0	0	0	0	9	0	0	1	10
	10	0	0	0	0	0	0	0	0	0	26	0	0	27
	70	0	0	0	0	0	0	0	0	0	0	15	0	15
	71	0	0	0	0	0	0	0	0	0	0	0	18	18
Randhäufigkeit		20	11	16	35	74	7	17	11	9	27	15	25	2139

N	2139
p0	0,82655446
pc	0,08576994

kappa	0,8102824

		20	11	16	35	74	7	17	11	9	27	15	25
1	20	400											
2	10		110										
3	15			240									
4	24				840								
5	79					5846							
6	19						133						
7	19							323					
8	11								121				
9	10									90			
10	27										729		
70	15											225	
71	18												450

	AHa →													
SSh ↓	Category	1	2	3	4	5	6	7	8	9	10	70	71	Total
	1	84	0	0	0	0	0	0	0	0	0	0	0	87
	2	0	8	0	0	0	0	0	0	0	0	0	0	8
	3	0	0	3	0	0	0	0	0	0	0	0	0	3
	4	0	0	0	37	0	0	0	0	0	0	0	0	40
	5	1	0	0	0	89	0	0	0	0	0	0	0	121
	6	0	2	0	0	0	1	0	0	0	1	0	0	7
	7	0	0	0	0	0	0	20	0	0	0	0	0	20
	8	0	0	0	0	2	0	0	5	0	0	0	0	7
	9	0	0	0	0	23	0	0	0	6	0	0	0	39
	10	1	0	0	0	0	0	0	0	0	27	0	0	36
	70	0	0	0	0	0	0	0	0	0	0	116	0	116
	71	0	0	0	0	0	0	0	0	0	0	0	32	33
Total		126	10	3	37	180	1	20	6	6	36	116	33	2975 2975

N	2975
p0	0,81142857
pc	0,0734277

kappa 0,79648493

		126	10	3	37	180	1	20	6	6	36	116	33
1	87	10962											
2	8		80										
3	3			9									
4	40				1480								
5	121					21780							
6	7						7						
7	20							400					
8	7								42				
9	39									234			
10	36										1296		
70	116											13456	
71	33												1089