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Risk Perception and Risk Communication in Medical Robotics

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Abstract: In the following there will be a presentation of a new highly topical, meaningful and continuously growing research field for risk perception and risk communication: medical robotics. A specific upstream mediation of risk perception is indispensable to successfully communicating risks as well as opportunities. There will be answers to the question how the definition of risk communication should be adjusted to medical robotics – especially surgical and rehabilitation/care robots - in order to give the public a feeling of safety and an high degree of risk maturity. The current scientifically verified aspects of risk perception and communication need to be expanded or rather adapted to the subject of medical robotics, as well as to lead an intensive debate with them.

Keywords*: risk perception, risk communication, medical robotics, risk maturity*

1. Introduction

To this day the sociological research of risk perception and communication has not addressed the subject of medical robotics. It is already frequently described as an "innovation power" [1] or even as a „sunrise industry" [2]. In the last 40 years a multitude of surgical and rehabilitation robots has been developed worldwide. They offer a wide range of possible applications, which always pursue one goal: clinical interventions and medical procedures must be more precise, with fewer complications and higher rates of success. The majority of medical robots are in an experimental state and on the verge of marketability [3]. On the homepage of MERODA an overview of all current surgical medical robots global, as well as their level of development is listed. According to this, there are alone in Germany currently 96 projects in the experimental phase. Germany only gets outperformed by the USA with 104 research projects. There are a total of 456 projects for navigation and robotics in computer-aided surgery overall. This does not even include the many other robotic systems, such as nursing and rehabilitation robot, contained within the medical robotics. Is gets obvious: the medical robotics is a significant ongoing research field. Doctors, surgeons, nursing staff, and other workers from the healthcare sector could be supported, but also replaced by medical robots. This is the reason why medical robotics is often described as the beginning of a revolution in medicine [4].

A wide range of scientific publications since 2008 are dedicated to the economic obstacles for products of medical technology on economic and political levels in Germany, for example by acatech in 2014[5] and two more in 2008[6] and 2009[7]. The German Federal Ministry of Education and Research (BMBF) published their study in 2008[8] and the German Government in 2012[9]. Also the Office of Technology Assessment at the German Bundestag (TAB) published studies with this kind of focus in 2010[10] as well as in June 2009[11] and December 2009[12]. With the publication of the VDE, the Association for Electrical, Electronic & Information Technologies, - one of the largest technical and scientific associations in Europe – in 2012[13], another important

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research facility discussed the future of medical technology. These studies refer primarily to improved forms of communication between research and development. The aspect of communication between laymen and experts only plays a marginal, or even an entirely excluded role. This is justified by the fact that the addressees are mainly research institutions. These highly relevant sources, however, illustrate clearly the enormous political, economic and social importance of medical robotics currently and in the future, especially for the German government, and are therefore used in this research. Medical robotics, as with general robotics, has the potential to create a “point of no return” [14]. This technology will permeate economy and society in the near future and change them on a revolutionary level. This will result in the need for new definitions of the words “human” and “machine” on a cultural level.

But at the same time, medical robotics is a research field with undefined risks. The future possibilities of technology are always varied. They have the potential for both negative and positive developments. Technologies principally accommodate the potential of the normative concept of a risk that should be avoided as a rule. Health inhabits a "conditional nature" [1] and therefore a special position in the innovation system, since it represents the basis for the implementation of other individual and societal goals. The definition of risks indicates that risks "in the judgment of the majority of people are considered as undesirable possible consequences of actions" [15]. These are "identified risks”, which serve as "mental constructs" in order to explain in more detail the potential hazards. Risks are also normative in terms of their nature and their accepted level and uncertain in terms of their relative frequency and their magnitude. As a result, they are associated with a high degree of uncertainty and risk of variable source to source of risk.
In this work, a clear distinction of the words “expert” and “layman” is given. Experts are defined as people, who - founded more or less scientifically - deal with the medical robotics. All other public figures are referred to here as laymen. The terms technique and technology are used interchangeably within the work, as well as laymen, community, society and the public.

Risk communication deals with an increased attention of public to risks by analyzing and identifying subliminal dangers and making the public more aware of the possibilities and associated risks. This is why risk communication is essential to the establishment of medical robotics. With the help of a public debate, medical robotics can be legitimized and socially accepted early on, in order to avoid – in the worst case scenario - an adverse reaction on the part of the public. Therefore, the most important aspects of risk perception and communication will be identified and evaluated in this paper by using standard reference works. A variety of definitions in the research field of risk perception and risk communication is given to date. By restricting on certain highly relevant works in the field of social sciences, a uniform definition can be ensured.

The goal is to clarify the diversity of risk perception and communication and come to the conclusion, that there is no simplified form of risk perception and communication in medical robotics, because of the variety of technologies and the wide range of possible applications. Debates need to be adapted to the specific subject matter. It is not possible to create a high rate of risk maturity of the laymen by discussing for example the subject of surgical robotics at the same time as rehabilitation robotics or even military medical robotics.

2. Important Aspects of Risk Perception in Medical Robotics

Risk acceptance depends symbiotically on the "evaluation of beliefs by their personal importance"[16]. What people assess as risks depends on the probability of its occurrence

and the extent of contextual risk properties, which are qualitative, intuitive and individually defined. "The spectrum of factors involved in acceptance is much more complex and varied"[16] than just quantitative factors.

A list of factors of risk perception that is adapted to the risk of medical robotics can be defined. This prevents that, despite the variety of quantitative aspects of risk perception, a uniform measure, without any inaccuracy and continuability of the factor list, while preventing "perspective constrictions" [17], is guaranteed.

Voluntariness is a crucial aspect of risk perception, but it is only partially present in the field of medical robotics, since the use of the technology in everyday life is not yet common. The technology will have to become part of cultural habit. That is why we have to focus on a careful process of adaptation by the public. Whether I can freely choose a treatment with medical robotics, is very relevant to the issue of acceptance of innovative technology in medical robotics. In the field of surgical medical robotics to this day patients at least have the option to choose an alternative, namely traditional surgery, but this option is not available to the same degree in nursing and rehabilitation robotics. There is no equal alternative. Since care and rehabilitation robotics is intended both to supplement care and rehabilitate disabled people, it is clear that is the field deals with completely new medical technology. The alternative are to either not use the technology or to choose a less effective method of treatment.

The scientific and technical maturity of the source of risk and the availability of equivalent alternatives are also relevant. The experimental nature of medical robotics is probably considered by the public as very risky. However, alternative forms of treatment are still an option. Regarding controllability, patients can opt for surgery using medical robots, but they cannot control its actual implementation in the operating room. The public must be able to avoid a technology and therefore exercise a degree of control over it. Treatment by care and rehabilitation robots, however, is arbitrarily controllable in its implementation. Usually the technologies can be switched off as needed.

There is still a risk that the innovative technology is established on the market, due to its economic benefits, without regard to the public. If medical robotics is prematurely put on the market without appropriate dialogue with the public, the laymen will feel like they do not have an economic say in the matter.

Damage, however, or the possibility for repair must be considered separately. Mistakes in operations that are caused by surgical robots often may not have the chance to be remedied. It is therefore difficult to get patients to accept the technology. Care robots do not have the same potential to do damage and there will therefore be less need to repair their mistakes.

Concerning the availability of trusted expertise - another very important aspect in the field of risk perception - , there is a lack of reliable knowledge and the public is uncertain about potential risks of the technology. It cannot be expected that individuals will voluntarily take on the risk, if experts cannot promise a lever of safety. The individual can only suspend voluntarily if the previously collected opinions concerning the risk technology probability is accurate. Other factors, such as an established trusted source of information also cannot be guaranteed at this point. Also, the public response to information from experts, whether it is regarded as credible, selfish, or just as an opinion, cannot be predicted. Whether the operator of the technology is trustworthy to the public, is speculative. It should be noted that, as manufacturers in scientific publications frequently note, that there is a notable overburdening of the expert with the innovative. "High

understanding by the user" [18] of the technology is important. To what extent surgeons and nurses currently possess such knowledge, as well as whether or not the public is aware of it and takes its risk perception into account, does not necessarily need to be determined at this point. It is important to consider these perquisites for a dialogue between experts and laymen, in order to avoid unnecessarily complicating acceptance by the public. Transparency is essential here. This applies also to the information the public receives by experts and the media. It should be noted that there will already be images of medical robotics in the minds of the people, for example because of movies and science-fiction stories.

The aspect of personal concern is relevant for medical robotics insofar that both privacy and the work place could be threatened. Surgical medical robots and robotic nurses intrude on the private sphere. A dialogue between experts and the public must determine whether or not this is desired. The aspect of innovative technologies, which may lead to a consensus break and a loss of confidence in experts, must be emphasized. Furthermore, surgical medical robots can make traditional surgeons and nursing obsolete. Medical robotics can be seen as a threat, although it also has the potential to add to and improve the work place. There is no objective assessment level.

On the one hand, benefits and risks appear symmetrically distributed in the field of surgical medical robotics. Anyone can voluntarily take on specific risks or avoid them. At a superficially level, there is no social group that would be comparatively more strongly and involuntarily exposed to potential risks. On the other hand, care robots are almost exclusively directed at an older generation. Risks associated with this technology would inevitably focus on social class and create disparity.

Medical robotics itself is inseparable from its technology: robotics. Particularly in the field of robotic care, individuals interact directly with the potential source of risk. In surgical medical robotics, experts have an impact on the technology and can control it. Care robots are normally designed so that the layman can act directly and autonomously with the technology. These points of direct exposure complicate acceptance. Furthermore, they are increasingly the subject of discussion by the public and media, which increases the risk of circulating misguided information.

The aspect of horribleness - another very important aspect in the field of risk perception – can be evaluated very differently. It should be noted, however, that it cannot be defined in the original sense, *i.e.*, as a disease that is painful and imperceptible to the senses. However, especially negative risks of medical robotics should not be trivialized. Risks that could take effect over a long period of time are not present in medical robotics. Disasters like a MCA do not happen in this field. In contrast, smaller risks can quickly occur, such as surgical errors. This is detrimental to the possibility of acceptance. Long-term damage in care and rehabilitation robotics, such as emotional neglect due to the replacement of nursing staff by robots, will probably only become apparent over a longer period of time. Just because an immediate negative reaction is not directly visible, potential long-term damage should not be overlooked. The potential risks of medical robotics do not normally affect more than one area, like the environment, economy or society. They are usually limited to the risk to the patient.

In conclusion, voluntariness and controllability, as well as the right of patients to have a say in research on risk perception are highly - which are normally considered as essential aspects in the risk perception – are explosive issues in the field of medical robotics too.

In addition to quantitative aspects, we also have to look at the qualitative factors. Within medical robotics, the source of risk is easily identifiable. Normally a specific

technical system is involved. The potential sources of error can be found mainly in manufacturing errors, like defective robots or operating errors by staff, where the difficulty of calculating the risk varies. A range of potential production errors can certainly be identified in each manufacturing plant. But application errors are individual and they therefore cannot be statistically predicted. This type of source of risk, in contrast to nuclear power plants in the vicinity, is separated from the areas of everyday life. In case of need of medical services, however, there is a confrontation with the source of risk.

Thus, the source of risk can be both directly and indirectly experienced first-hand as well as through the media. In risk perception, this would be a particularly isolated case. In conclusion, not only is it necessary to have a form of risk communication that is adapted to medical robotics but it is also necessary to be able to differentiate according to the focus of the discipline.

3. Important Aspects in Risk Communication for Medical Robotics

Based on transparency, participation of laymen in the decision-making discourse needs to be highlighted. The possibility of participation in decision-making gives the layman the impression of transparency and increases the likelihood of acceptance. This inevitably means an appropriate level of orientation towards the audience.

The concerns expressed by experts in the case of the right to access information - with the goal of self-directed risk-taking in correlation with keeping sensitive data confidential - can be adjusted in the field of medical robotics, for example, to patient files. We can assume that there is data that would be inappropriate for laymen to have access to, for example because of their inability to objectively consider it. The necessary weighing of information nowadays, because of the huge amount, must be disclosed in an understandable way on the part of the communicators. For example, a government-organized public warning against certain products of medical robotics is extremely economically negative for the manufacturer. The ultimate goals of successful risk communication are to reduce distrust, inspire trust, and foster acceptance. Anything beyond that requires legal regulation. Manufacturers of innovative products should therefore take advantage of the possibility of self-disclosure of information. Only then [-] the aforementioned necessary interaction in risk communication can be guaranteed. Mutual prejudices and fears can be reduced in this way. However, these are aspects of successful risk management - that is, creating a proportionate balance between production and citizens' interests - and therefore they should not be discussed in further detail.

Regarding the aspect of timely exposure in risk communication and therefore the aspect of credibility, it gets clear that proven sources of information – or the missing of them - may provide a huge obstacle to medical robotics, since almost no communicators have emerged to date. Thus, societal familiarity has not yet been established. It would be advisable to establish such communicators early on, in order to gradually establish communication based on reliability, unselfishness, competence and accountability. It cannot be expected that unknown communicators will be accepted by the public.

It is very important to medical robotics to provide information and action plans in order to communicate individual risk as well as the individual approach to risk. In order to enable the layman to deal with the fact that absolute safety is not possible, comprehensive strategies must be developed by the communicators with the help of new guidelines. This must be based on incomplete information – a frequently state in the medical robotics due to its innovative stand.

It is realistic to say that in the coming years there will be potential risks of medical robotics which will be realized in the hospital and nursing environment. It is important to communicate to the laymen that they will have the capacity to act and control their treatment, so that they do not feel powerless. Preparation in case of emergency should be conducted, so that the layman can arrange and customize their living situations according to the source of risk.

Furthermore, communication must be adapted to the public. Communicating with laymen in the jargon of experts not only hinders dialogue, but it also inevitably leads to difficulties in acceptance. Recently, a targeted risk communication has been required. [19] Communication that is adapted to the layman is supposed to stimulate the feeling of credibility and acceptance, and promote understanding as a result. However, this represents a higher level of effort for risk communication, since such groups must first be identified. It should be noted that depending on the risk group - for example for currently sick patients, healthy patients, doctors, and nurses –other forms of communication must be created. These groups, however, can be further differentiated, for example by gender, age and origin.

4. Concluding Remarks

Medical robotics possesses extreme forms of risk perception and communication. The risk perception differs between experts and laymen in an emotional way. Many hopes and wishes are catalyzed by medical robotics. Voluntariness and controllability are almost not present at all in the medical robotics. It should be noted that objectivity in the consideration of medical robotics can therefore not be provided.

Intuition is the key component in the perception of risk by the individual. Emotional reactions to innovative technologies are deeply embedded in the human psyche. As a result, it should never be the aim to manipulate emotions. The only feasible and therefore essential option is to explore the possible scope of action and use "the formability of the technology" [20], in order to align it to the needs of society. This means that new technologies - medical robotics in particular - need to be accompanied by social debate.

Risk perception of a technology is, as stated above, strongly dependent on how far society feels that it can shape and understand the technology. When there is no feeling that the technology can be controlled or that it can be understood, people feel limited in their actions and have an increased tendency to reject the new, possibly meaningful and useful innovation, despite its advantages. In the future, these preconditions for the acceptance of technology should be strongly supported, so that society does not perceive upcoming innovations in medical robotics as a threat. Suggestions for the smooth introduction of new innovations in the field of medical robotics should be developed in the future, in collaboration with society. Technology Assessment (TA) could accomplish this. With the help of scientific analysis, TA evaluates and identifies the consequences for society that are associated with the use of technology. Because the future is uncertain, an assessment of the impact of technology can never guarantee an anticipation of all possible adverse effects. However, the TA can identify potential positive and negative consequences, and based on this knowledge it can harmonize the possibilities of modifications and launch conditions with the developers of technology and technology users. To do this, the same discursive methods are needed, just as they are used in risk communication. A key part of TA is therefore social discourse. However, often the influence of the media is neglected, in the form of transmission of technological knowledge to the society. Therefore, an intersection with risk communication is needed, which explicitly addresses this aspect.

The societal confidence in experts in the field of medical robotics is sensitive and may already be damaged. Furthermore, for decades, media generated images have shaped the public view of robotics, which may have had a negative impact on acceptance. It is likely that this technology already instills a lot of fear. Since this is a very new field of research, hardly any experts, or people with science-based knowledge on the subject, speak about this research field; rather mostly laymen discuss the technology.

Risk communication can be oriented towards recipients if all significant, normative aspects of risk perception are scientifically established. This work could only provide a theoretical framework that must be scientifically proven. Medical robotics must be legitimized in advance, since the topic of health is particularly fraught with conflicting emotions. However scientific journalism alone could not overcome these obstacles. It is understandable to try to depict the potential risks of a technology in the media in the right light, but in practice, it is not viable. It contradicts of the fact that limited information prevents information overload. Media communication systems cannot control risks or deal with them. A variety of institutions are responsible for this. The task of the media is to create a public discussion on the internal and external problems of society.

Research is never independent or isolated. These dependencies must be addressed in a form of risk communication that is adapted to the needs of laymen. The research must not only translate information, but it must also provide an analysis of potentially hidden interests and intentions of researchers, as well as give answers to what this means for individual courses of action. Scientific journalism must act as a translator between experts, the public and the media.

How can scientific journalism create credibility? Very important is a balanced and critical reporting on the topic. Thus, objective risks do not exist and cannot be compared or processed in the media. Weighing potential damages or risks is the same as judging them. The construction of risks by experts usually inspires more confidence. However, the societal framework for defining risks should always be taken into consideration. Different perceptions of risk by experts and by laymen can co-exist and be equally justified. These "conflicting constructions of reality" [21] and "the societal and political processes of examination of different risk perceptions by different actors" [21] must be integrated in the media. The way the media reports on the risk is probably not a decisive factor as the risk itself, but it does determine the "intensity of the treatment of risk in the political system" [21].

Communicating risks in a way that has been adapted to medical robotics, must take place at several levels. An open-ended dialogue is needed to reduce problems of acceptance by society. But communication between doctor and patient in order to raise awareness of risks and side effects must also come into play. It is a matter of two distinct but highly essential situations for communication. Dialogue must act both as a source of information, about the nature and extent of risks and it must communicate meaningful individual and social interaction. At this second level, all parties have equal rights. This must be guaranteed. As a result, it increases the likelihood of mutual understanding.

In the field of medical robotics, experiences from the past are missing. Accurate assertions about potential future risks are therefore hardly possible. Learning by trial and error will arise in the medical robotics to date.With respect to an evaluation of realized risks in the history of the research field of medical robotics and their significance for the individual risk perception, an extremely small amount of source material was given. Learning from the past has not been established to date.

However, the impression that risk potential can be controlled has to be communicated to society. Only the vague categories of controlled risks and residual risks are possible in analyzing the risks of medical robotics. This would mean that experts implicitly define a limit for risk acceptance by the society. It would be more advisable to integrate the concept of a "wild card" into considerations of safety. This is a "surprising and extremely consequential event"[22], but it is not known when it will occur. All potential incidents should be taken into account, rather than to rely on unrealistic or barely tolerable risks.

A specific upstream mediation of risk perception in medical robotics is indispensable to successfully communicating risks as well as opportunities. All in all, successful risk communication is only conceivable if the forms of communication are analyzed by the communicators, the target groups are defined, and communication is adjusted. Political institutions and similar organizations must react to innovative technologies by providing public discussion in the form of discourse analysis. They must contribute to an informed discussion and not only let the media coverage deal with risky technologies.

The political-administrative system is confronted with new challenges. Risk governance refers to these institutions and helps establish a risk management. Organization and procedure must be adapted to new problems. By involving the various stakeholders of the research field medical robotics and the broader legal, political, economic and social contexts, the potential human and economic costs, caused by disasters, can be avoided or at least reduced. It calls for a socially compatible technology design. A participatory and open-ended identification of risk must be ensured. The sunrise industry medical robotics inhabits a large variety of participants. Only by regarding them all, a highly promising way of risk perception and risk communication and therefore a safety in the field of public health can be established.

Therefore, depending on the risk of an innovative technology, a different perspective on the problem is required. Risk decisions will always be controversial due to the complexity of risk perception. Only a compromise via a fair process is possible. A certain way of looking at the problem is connected to the choice of a strategy of security.

In the future, individual aspects of risk perception and communication must be appropriately adapted and established. However, technology is not the only way to solve future problems and it must be guided by social debate. It should not be the primary goal to increase acceptance of the technology. The use of medical robots of any kind is advantageous only if its implementation is more accurate, safer, gentler, more profitable, and faster than the alternatives. The absence of these conditions in the application of the technology prevents people from objectively evaluating it, because it channels their desires and hopes. It is important to avoid a “technological euphoria.”

Faster innovations in the AI research like cognitive systems or cloud robotics, social robots – humanlike robots – and the future ubiquity of robots (industry 4.0) and distance loss to them at the work place, housekeeping or even driving, will increase the need for discourses. In the future medical robotics – and robotics in general – will be part of our everyday life. Now is the time to give the public a high degree of risk maturity to define the ways in which the technology can be integrated in our lives.

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