Risk Engineering

Martina Raue
Bernhard Streicher
Eva Lermer *Editors*

Perceived Safety

A Multidisciplinary Perspective

Springer

Risk Engineering

Series editor

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The Springer Book Series Risk Engineering can be considered as a starting point, looking from different views at Risks in Science, Engineering and Society. The book series publishes intense and detailed discussions of the various types of risks, causalities and risk assessment procedures. Although the book series is rooted in engineering, it goes beyond the thematic limitation, since decisions related to risks are never based on technical information alone. Therefore issues of “perceived safety and security” or “risk judgment” are compulsory when discussing technical risks, natural hazards, (environmental) health and social risks. One may argue that social risks are not related to technical risks, however it is well known that social risks are the highest risks for humans and are therefore immanent in all risk trade-offs. The book series tries to cover the discussion of all aspects of risks, hereby crossing the borders of scientific areas.

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To Niels

Preface

Humans are inherently curious—from the very start of our lives, we strive to explore our environment. Children want to know what happens when they drop their plate or whether a pen can draw on the wall. As adults, we are in constant search for information about the world around us. This immanent curiosity is a driving force of human, social, and technological development. Innovation involves taking risks, but while being inherently curious, humans have a tendency toward risk avoidance. As a result, curiosity alone often does not induce progress because humans are also driven by a need for safety, control, and predictability.

Being curious and valuing safety are two sides of the same coin when it comes to taking risks. Thus, finding a balance between these two drivers of motivation is a major challenge for individuals, organizations, and societies. Researchers of various disciplines have extensively studied risk and uncertainty, but also implicitly acknowledged the role of certainty as a counter-pole. However, safety as a human need and motive has received considerably less attention than risk in academic research. On the one hand, life in western societies has become increasingly safe due to better standards in public health and policy, which have decreased risks for everyone. Accordingly, products and services concerning safety are considered one of the biggest industries in the world. On the other hand, our modern world often merely suggests safety or attempts to create a sense of safety when, in fact, complete safety is unattainable. The marketing industry, for example, advertises cars with innovative technologies that make driving safer than ever before—but driving remains one of the riskiest activities we engage in. Thus, the term safety often reflects a reduction in risk rather than the absence of harm and addresses the human need to *feel* safe. This volume aims to gain a better understanding of the role safety plays in our society and various disciplines, how humans perceive risks but also need safety, and how this understanding can lead to a culture that better supports people in their decision-making processes.

In this volume, researchers in engineering, philosophy, and psychology shed some light on the mechanisms of safety. In Chap. 1, Dirk Proske defines of terms related to safety from an engineering perspective and discusses whether optimal safety can be achieved. In Chap. 2, Dirk Proske discusses the categorization of risks and safety and the limits of such categorizations. In Chap. 3, Niels Gottschalk-Mazouz takes a philosophical perspective on terminology related to safety and introduces the term risk culture, thereby discussing rational and moral aspects of risk-taking and risk governance. In Chap. 4, Eric Eller and Dieter Frey take a psychological perspective by considering basic human needs and social determinants of perceived safety. In Chap. 5, Martina Raue and Elisabeth Schneider also take a psychological perspective and focus on human decision-making strategies. In Chap. 6, Eva Lermer, Bernhard Streicher, Martina Raue, and Dieter Frey shed some light on different factors underlying the assessment of risk. Chapters 7, 8, and 9 have a more applied focus. In Chap. 7, Susanne Gaube, Eva Lermer, and Peter Fischer discuss the relationship between risk perception and health-related behavior, while in Chap. 8, Robert Mauro addresses conflicts between facts and fears in aviation. Finally, risk sports are the focus of Chap. 9, in which Martina Raue, Bernhard Streicher, Eva Lermer, and Dieter Frey introduce several studies on the influence of physical activity on risk perception.

We would like to thank all of the authors for their valuable contributions in making this volume a multifaceted work that crosses disciplinary borders.

Cambridge, USA — Martina Raue
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About the Editors

Martina Raue is a Research Scientist at the MIT AgeLab in Cambridge, Massachusetts, and an instructor in the Department of Psychology at Harvard University. She studies risk perception and decision-making over the life span, with a focus on the roles of time and emotion. She applies theories from social psychology to challenges and risks of longevity and examines ways to improve planning and preparing for later life. She received her Ph.D. in social psychology from the Ludwig Maximilian University Munich in Germany and her master's degree in psychology from the University of Basel in Switzerland.

Bernhard Streicher is a Full Professor of Social and Personality Psychology and Head of the Department of Psychology and Medical Sciences at the University for Health Sciences—UMIT in Hall, Tyrol in Austria. His research interests include the psychological mechanisms of decision-making under risk and uncertainty and the question of how to enhance the risk competencies of people and organizations. In addition to his scientific research, he works as a lecturer and consultant regarding the topic of 'risk' for profit and nonprofit organizations. He received his academic titles from the Ludwig Maximilian University Munich in Germany.

Eva Lermer is a Professor of Business Psychology at the FOM University of Applied Sciences for Economics and Management in Munich, Germany, and a Research Scientist in the Department of Experimental Psychology at the University of Regensburg, Germany. Her research interests include subjective risk assessment, decision-making, and de-biasing strategies. In addition to her scientific research, she works as consultant for profit and nonprofit organizations. She received her academic degrees from the University of Salzburg in Austria and the Ludwig Maximilian University Munich in Germany.

Martina Raue, Bernhard Streicher, and Eva Lermer jointly founded the *Risikolabor* (risk lab) at the Ludwig Maximilian University Munich in 2011. While currently based at different institutions, they continue to collaborate on various research projects investigating human perception of risk and influences on risk-taking behavior. In addition, they offer consulting and workshops on the topic. More about their work can be found at www.risikolabor.org.

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Part I
Theoretical Aspects of Perceived Safety

Chapter 1
What Is "Safety" and Is There "Optimal Safety" in Engineering?

Dirk Proske

Abstract In this section a definition of the term "safety" based on freedom of resources is introduced. Such freedom of resources can also be used for the definition of the terms "danger" and "disaster". Additionally, the terms "safety", "danger" and "disaster" can be correlated to time horizons of planning. The introduced relationships will then be used for the discussion whether "optimal safety" is achievable or not. Currently, "optimal safety" is being intensively discussed in many disciplines such as the field of structural safety. Considering the definition of "safety", this paper will show that "optimal safety" is rather a theoretical issue and cannot be achieved under real world conditions. This statement fits very well not only to considerations in the field of system theory, but also to empirical observations. It is suggested that the term "optimal safety" is introduced as an assurance measure for engineers rather than for the public. As a solution the concept of integral risk management is introduced. One of the properties of this concept is the possibility of continuous improvement and therefore no optimal solution is claimed.

Keywords Safety · Risk · Optimal safety · Resources · Quality of life · Risk cycle

1.1 Introduction

1.1.1 Current Developments

Over the last few years the question of optimal safety has been intensively discussed in many fields such as structural engineering. The question of optimal safety considers the selection of safety measures regarding minimum costs including

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failure costs. For example, building a weak and cheap construction which will fail and has to be re-build regularly or building a very strong and expensive structure which will remain for a long time without failure. This question of optimal safety is of particular interest for the development of general safety requirements related to all technical products, such as building structures, airplanes, cars etc. For example, within the last decades, the general safety concept in structural engineering has been updated from a simple global safety factor concept to a safety concept which is based on probabilistic issues and which is able to adequately consider such questions. Therefore, the update to the new safety concept initiated debates regarding the optimal safety of structures.

The question of optimal safety has been mainly answered through the economical optimization of the spending of resources. This includes the important and true consideration that resources for humans and societies are limited.

In structural engineering, usually the sum, the overall costs of the production cost and the cost of failure (disadvantages) are compared with the possible gains of creating such a structure (advantages). The combination of these two cost components as shown in Fig. 1.1 yield to an overall cost function with a minimum value according to some adaptable structural design parameters included. Such design parameters can be, for example, the strength of the building material or the geometries. This overall cost function is based on economic considerations. It is actually a cost-benefit analysis, or, how it may be called here: an advantage-disadvantage-analysis. The difference between an advantage-disadvantage-analysis and a cost-benefit-analysis is the inclusion of further advantages and disadvantages, which might not be directly presented as economic values. For example, sometimes additional measures such as those found within the quality of life parameters are incorporated. Dimensions of such factors are shown in Fig. 1.2 which provides a good impression regarding the diversity and the scale of such factors. The application of such quality of life parameters has a long tradition in medicine and has been applied in structural engineering for approximately two decades. For example, the Life Quality Index (LQI) by Nathwani et al. (1997) has become widely used in several engineering fields (Proske 2004; 2009).

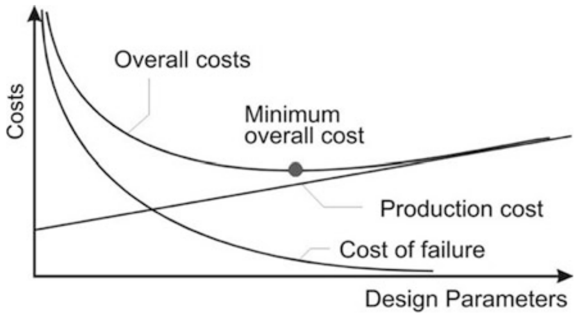

Fig. 1.1 Widely used function of overall structural cost depending on several parameters

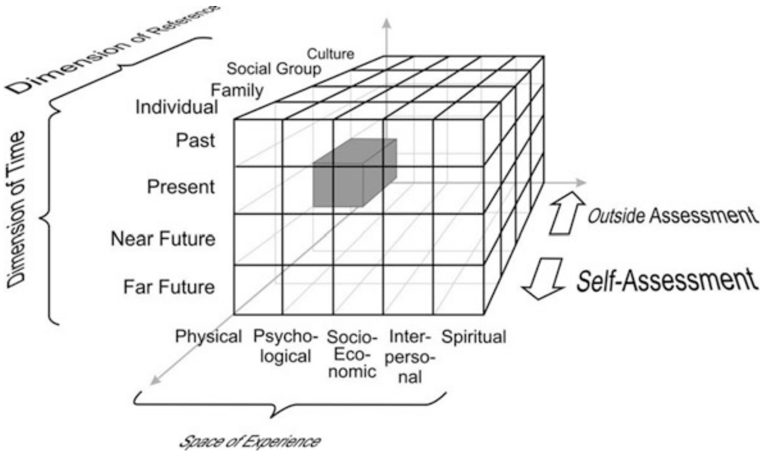

Fig. 1.2 Dimension of quality of life according to Küchler and Schreiber (1989)

1.1.2 Limitation of the Current Developments

Although the search for performance measures as a basis of optimization procedures has in many fields yielded to the application of quality of life parameters, it does not necessarily mean that this strategy has been successful. It shows only that entirely pecuniary-based performance measures might be insufficient. If one considers for example the history of quality of life measures in medicine since 1948, one will find that now a huge variety of such parameters (up to 1500 according to Porzsolt and Rist 1997, Kaspar 2004) have been developed for very special applications. Such a specialization requires major assumptions inside the parameters. For example, the LQI assumes a trade-off between working time and leisure time for individuals. Although this might be true for some people, most people enjoy working (von Cube 1997) if the working conditions and the working content fit to personal preferences. The choice of using the average lifetime as a major indicator for damage has also been criticized (Proske 2004, but see also Müller 2002). The question, whether a quality of life parameter can be constructed on only a very limited number of parameters to be applicable still remains. Again, Fig. 1.2 should be mentioned as giving an impression about the dimensions of quality of life (Küchler and Schreiber 1989).

The comparison between the different dimensions and the simplified definition of the LQI makes limitations visible. For example, many psychological effects are not considered in the LQI. Since people are so strongly affected by their individual, social and cultural experience, these effects can rarely be excluded in useful quality of life measures and even further in decision-making processes. Many works have been done in this field such as Fischhoff et al. (1981), Slovic (1999), Covello (1991), Zwick and Renn (2002) or Schütz et al. (2003). For a general summary see Proske (2009).

Returning to the original question, the terms "safety" and "optimal safety" still need to be defined.

1.2 Terms

1.2.1 The Term "Safety"

The term "safety" is often defined as a situation with a lower risk compared to an acceptable risk or a situation "without any danger impending" (Proske 2009). Other definitions describe safety as "peace of mind". Whereas the first definition that uses the term "risk" is already based on a substitution, the term "peace of mind" is a more general definition. The author considers "safety" to be the result of an evaluation process of a certain situation. The evaluation can be carried out by every system that is able to perform a decision-making process, such as animals, humans, societies or computers (which use algorithms). However, algorithms usually use some numerical representation. The following equation shows an example from a code of practice of defining safety S when the existing risk R is less than an allowable risk:

$$\begin{aligned} \text{existing}\, R &\leq \text{permitted}\, R \rightarrow S \\ \text{existing}\, R &> \text{permitted}\, R \rightarrow \not{S} \end{aligned}$$

Also, the author considers human feelings as a result of a decision-making process. Therefore, safety is understood here as a feeling; safety is a perception. Furthermore, the decision-making process deals with the question whether some resources have to be spent to decrease hazards and danger to an acceptable level or not, for example spending money for mitigation measures. In other terms "safety" is a feeling that no further resources have to be spent to decrease any threats. If one considers the term "no further resources have to be spent" as a degree of freedom of resources, one can define "safety" as a value of a function which includes the degree of freedom of resources. Furthermore, one can assume that the degree of freedom is related to some degree of distress and relaxation. Whereas in safe conditions relaxation occurs, in dangerous situations a high degree of distress is clearly reached.

The possible shape of the function between degree of relaxation, which ranges from "danger" to "peace of mind," and the value of the function as degree of freedom of resources is shown in Fig. 1.3. The degree of freedom of resources describes the extent to which a person or a society can decide on the use of its own resources independently of external influences. It is assumed here that the relationship is non-linear with at least one region of over-proportional growth of the relative freedom of resources. In Fig. 1.3 this region of over-proportional growth is defined as the starting point of the safety region: