Determinants of Decision-making in Risky situations

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In this paper, issues on decision-making in risky situations are discussed. There are two levels of criteria for making decisions: personally preferred ones and rationally bound ones. The former might be more attractive to an individual but the latter may be expected in a societal context, or in a teaching situation. We use the health context to describe our ideas on the ingredients of situations where people are confronted with uncertainty of the outcome of a decision and have to take an action for themselves.

Systems analytic approach

In applied statistics, long before the data are collected, the situation at hand has to be investigated. What are the study questions? What is the target? How can one measure whether this target is reached at? Which variables influence the target variable? What are the confounding variables that blur the relations between influence variables and target variables? Are there any hypotheses about them? What are the underlying assumptions? How can one get reliable data? The target is to make a decision objective and optimize the future outcome – be it in the sense of expected outcome or in minimizing probabilities of specific events. The basic assumption in decision making approaches is that there is a *unique* rationality to use, which leads to a well fitting (unique) model and a well-based optimal solution. The assumption ignores the fact that decisions often involve different stakeholders whose interests lead them to maximize their own benefit. This may lead to various forms of rationality and for some stakeholders to reject the rationality used by others as not well-founded. We will elaborate our ideas about decision situations with the aim of empowering all the persons in a decision to come jointly to decisions, which improve the outcome for all stakeholders involved.

Types of risk

By risk we understand a situation with inherent uncertainty about the (future) outcomes, which are related to impact (cost, damage, or benefit). Sometimes expected value is used for comparing several decisions, which are ‘at stake’. Risk is used heterogeneously, some refer only to the probability inherent to one adverse outcome without regarding its impact, and others refer only to the adverse outcome. A decision between several choices of action might involve one person, or a decision might be “shared” between two or more stakeholders, eg., a patient and a doctor who have to find a decision about the next steps. A decision might also bring together two stakeholders who never “meet”: a health institution that implements a specific regime of screening for a disease and a person that wants to take precautionary steps for preserving his health. An example is mammography to detect breast cancer as early as possible and a woman in the 30s who wants to do the best for her health even though she has no symptoms. Risk involves two components and both are prone to subjective interpretations: the judgment of impact is different for different individuals and is even more distinct for a person or an institution with a role different from the patient.

Rationality in decisions

Situations with uncertainty encompass also emotions and desires. Especially in health issues, such features have a big impact. To evaluate decisions, the possibilities have to be known as well as a judgment of the probabilities has to be expressed, and the evidence available has to be judged. Evidence comprises hard facts, evidence-based knowledge and more or less subjectively formed beliefs partially resulting from memory or extended from anecdotal information. Baron (2008, pp 12) discriminates several types of thinking and how they influence the framework of inference:

Diagnosis is a search for the cause of an unwanted situation such as a patient suffering from specific symptoms. *Scientific thinking* encompasses testing some hypotheses on the nature of a phenomenon, such as the causes of a specific disease. Setting the goals is more arbitrary and may be freely decided by the thinker than in the diagnosis problem. *Reflection* aims at deriving general principles or rules, mainly by a hermeneutic discourse piling evidence from memory or scientific literature. What is counted and searched for as evidence is more under the control of the researcher than in scientific thinking. *Insight problems* are where solutions come into mind after some futile efforts, the solution is indisputably correct or not. Such problems include Sudokus or puzzles used in intelligence tests. *Prediction* of how the future will develop is similar to reflection but with a specific target. *Behavioural learning* is a type of learning from the result of our behaviour, or learning from the result of a planned behaviour, which can be similar to an experiment in science. It is a kind of learning by trial and success favouring decisions that proved successful in the past. *Learning from observation* covers situations of learning from observing without intentional experimentation. Evidence is not controlled by the thinker except for the possibility to accept or ignore it.

While such criteria form the basis of rationality, there will still be a clash between the different groups in a decision: the research community in medicine, public institutions in charge for administering schemes to guarantee quality in the health sector, hospitals, doctors, and patients; they all have their expectations from the decisions to be made, and they all have different responsibilities in the decisions, and finally they have to bear the consequences of the decisions differently. People have to be empowered in the social strategies on how to communicate about inherent risks as well as the mathematical concepts involved.

Implementing rationality

Information in health issues is mainly backed up by statistical methods, decisions are heavily evidence-based and supported by probability models. To increase rationality in dealing with such information usually the methodology of empirical research is advocated. As the methods involved are complex and mathematical concepts are rarely well understood, the endeavour of those who are concerned to improve the quality of decisions, is focused towards statistics with approaches and strategies to understand the given methods more easily. A common example relates to the correct probability to have breast cancer for a woman whose mammography has shown a positive result. A probability that normally is ‘estimated’ by gynaecologists (the special doctors who should know better) to be much higher than 90% but is – according to the available information about the diagnosing procedure – only about 11% for a 40 year old woman in a screening test. Such a probability is dependent on the prevalence to have breast cancer, which differs significantly by age. For details see Gigerenzer (2002) or recommendations about mammography as in Mayo Clinic (n.d.)

However, this approach is conceived in a framework which is far too narrow. It presupposes that there are probabilities of the diagnosing procedure to err in both cases of a woman with and without cancer of the breast; it also presupposes also that there is something like a probability (prevalence) of this cancer among women of this age. It suggests that women of this age are equal while there is an argument against such an averaging view. It also suggests that the result of the mathematical approach applies in the same manner for all stakeholders, ie., the single woman tested, the doctor who investigates her, the hospital that has installed the equipment for the mammography, and the national or regional health institutions that have promoted the scheme of screening as necessary. In fact this is far from true, as will be shown below. From the deliberations below it will be clear that the stakeholders differ in their role so much that no common rationality can be found as a unifying element. Furthermore, it will be clearer that for all people involved, the criteria for their decisions (to join the screening etc) are signified by ideas that are beyond what usually is perceived as rational. To empower people to understand the statistics is only one step in the right direction. To improve the decisions and the management of risk it is necessary to derive a more holistic view on the situation.

Rationality differs with the role one plays in the decision. One important issue here is that the different stakeholders bear the consequences of a decision in a completely different way: A woman with a false positive test result has to carry the burden of further, more invasive procedures to complete the diagnosis. The doctors have to take into account that if they fail to detect a cancer they might be held liable. A health ministry that has installed a mammography device has to justify its cost as being worthwhile for the community. They follow different targets which require different criteria to evaluate their decisions. We use a systems analysis approach to extend the perspective and the comprehension of a decision that finally has to be shared between unequal stakeholders. We will focus on the following four ingredients and two substantially different types of situations, which we call *real* and *virtual* risks.

Ingredients of risky situations

The main ingredients of a decision situation are: the nature of the risk (and mathematical concepts like probability); the psychological matters involved; the type of situation (treatment, prevention) and information used; the people involved, their aims (purpose) and their inherent criteria.

Type of situations

Here we will assume that at least two stakeholders are involved – this situation differs from when there is only one person involved such as undertaking a risky hobby or in nutrition. Personal risks comprise issues like travelling, smoking, nutrition, personal health issues – where the state or others do get involved, if only in regulation. Societal risks include, screening schemes for diseases, vaccination programmes, epidemics, catastrophes like floods or atomic accidents, climate change, and war.

Structurally, there are two very different types of situations: *real* risk with a severe impact already (a broken leg, for example) and an action has to be taken to avoid more damage; and *virtual* risk, where is a potential risk (of cancer, for example) which currently poses no real constraints. In the case of treatment of a severe disease like cancer people develop an awareness during the progress of the disease; however, in the case of prevention they mainly rely on information that is transmitted by the media and the health system (including the advising doctor). They (including the doctors) may lack a sound understanding of the underlying concepts and generally over-rely on the accuracy of the measurements. A sound control of the validity of the measurements is not always undertaken and is hard to perform; for example, how to evaluate the success of vaccination against flu?

In the prevention case, the risk may be vastly over-estimated, as does happen in the case of screening programmes for cancer. The criterion to measure their success is the net gain in lifetime (scaled by the quality of life). However, this is not open to measuring. Sandblom et al (2011) have tried to evaluate the success of screening for prostate cancer with the result that a success of the programme cannot be shown. In the case of BSE, from the tiny virtual risk of it, it may be that there is a non-negligible probability that all positive test results might have been false positives (see Dubben, 2005). Once a decision has been made, and many measurements have been taken, there is a tendency in human beings to judge it as necessary, otherwise the decision maker would lose credit; people who engaged in the issue would have to reflect about potential errors. This is the perennial dilemma for societal risks.

People involved

The pharmacology industry has a substantial role to play and, while there have been many significant advances in medicine, their role is also commercial and may not invariably be in the interests of the public.

Thus industries produce screening machines , which then need to be justified by good use, which may come at quite a high cost. The public health service bears the brunt of these costs in much of Europe. The public and the media have roles to play – the latter wants to sell information, which is easier when risks are higher or presented as such: the public wants to know and yet can be mis-informed by the media. The medical profession is a conduit between the media and the public and generally on the side of the latter, and yet can be heavily influenced by the former, especially when negative stories are published: a recent example was the MMR vaccine (see Goldacre, 2008), where the media tried to give a 'balanced' view by publishing the ideas of a 'rogue' doctor, whose work was later discredited and yet had a severe adverse effect of many babies not being immunized, as strongly promoted by the public health service. Of course, the legal system also has a part to play: doctors may fear litigation and so give either neutral or no advice in some cases, to the detriment of patients who end up being confused. The status of medicine is thereby adversely affected.

No person involved acts objectively, or neutrally, or free of personal (or institutional) interest. One important aspect is to focus on the relevant criteria either used or in the background and how the stakeholders understand the concepts involved (medical and mathematical). People's subjective probabilities can vary greatly in the same situation, especially if their perspectives and interests are also different. Individuals working with screening equipment or promoting certain drugs can have very different probabilities for the same event (see the Lipitor example below). Doctors have the need to be recognized as experts or important people and want to avoid legal problems.

An example for risk communication

We mention a further example of Lipitor (a statin) used for the prevention of heart infarctions. Before proceeding, we make clear that we have no medical expertise and therefore take no view on whether or not Lipitor is effective; we are simply trying to raise and discuss the underlying statistical issues. We should also state that it is clear that there have been many advances in medicine, which have led to much better health. Indeed, one of the origins of statistics, and even the term itself, was linked to the improvement of health. Here we discuss some of the statistical limitations in order to promote debate. Advertisements present the promise of risk reduction communicating both absolute and relative risks; yet the relative risks are in large characters, while information on absolute risks is written in tiny characters in a footnote: "In patients with multiple risk factors for heart disease, Lipitor reduces risk of heart attack by 36%", with a footnote saying "… in a large clinical study, 3% of patients taking a sugar pill or placebo had a heart attack compared to 2% of patients taking Lipitor."

The absolute reduction of risk is from 3% to 2%, which amounts to 1% point. As such a figure might not impress deeply, one could prefer to express the risk reduction by relative figures: 1% reduction from 3% amounts relatively to a decrease of 33% (the 36 stem from more accurate figures). The different components of the problem are legitimate but lead to a complete different view of the situation: The absolute reduction in risk is low, while the relative reduction in risk is high. The differing format of information as percents and as absolute numbers can blur or enhance the numbers involved: percentages are more difficult to understand, absolute numbers express more clearly the circumstance but cannot be processed as probabilities and give the impression that the data is exact, ie without sampling variation. The statements are based on a study by McCormack, T.; & Minhas, R. (2007). In terms of a statistical evaluation of the study, some more questions about the quality of the data should be answered: Is this a controlled study? How were the patients recruited and attributed to Lipitor and non-Lipitor? Is the sample representative for the population (high-risk group with a risk of 2 to 3 %, which generally is around 0.5% for 45+)? How long does a person with a higher risk have to take the medicament to benefit from it?

There is a clash of interest between different parties. More emancipated patients do ask for access to more information, following the lines of arguments of a medical consumer organization; see Center for Medical Consumers (2007). There is a huge market for all statin drugs of $35 billion in annual sales worldwide. The long-term usage might have more unwanted side effects than expected and bear the risk of severe side effects such as cross reactions (like rhabdomyolysis) to other medical prescriptions. The effect appears to be valid only for high risk men between 30 and 69 years. The magnitude of this benefit, however, is not high as only 1.5% fewer of those taking a statin will suffer a non-fatal heart attack. Moreover the proven benefit in case of an existing heart disease has to be separated from the usage of the medical drug as a long-term measurement of precaution in patients with slightly higher risks than usual. The design of the "study" may not have been sound: It is based on an analysis of medical records of British heart patients (an observational database) – which may only be hypothesis-generating.

Gigerenzer (2002) interviewed medical doctors and notes that they do not have a clear understanding of the probabilistic information they use and which is vital for their decisions to be 'rational'. He and his school develop embodiments of methods, which are directly comprehensible. For example, he has taken up the old idea of a 'statistical village' calculating expected values for the cells of a (two-way) cross-classification calling it natural frequencies (Gigerenzer uses tree diagrams instead of contingency tables to display the numbers). By column or row percentages (or proportions) the corresponding conditional probabilities may be replaced. His empirical studies show a remarkable increase in correct solutions in Bayesian problems, which is hopefully linked also with an increase of comprehension.

We go on to discuss information and its provenance and quality, crucial elements of any statistical work, but too easily ignored, especially by the media. The space of decisions taken into account crucially influences the actual decision. Which treatments are available? Which complementary measurements may be taken and increase the benefit of the treatment? Which scenario is likely to emerge? Which precautions might protect from them? And how to get information for judging the situation and the measurements to be taken? To get valid information has always been difficult and nothing has changed in times of the Internet. More important, good information is often hard to understand as it involves mathematical concepts and statements on the basis of models or scenarios, which are bound to (hidden) restrictions. Even for experts it may be hard to judge the value of information as it may be given with a basis emerging from an interest on the side of the supplier of the information. Sometimes it would not only be costly but useless to involve an expert for clarification as an expert for short-term consequences may lack the expertise for long-term issues.

If there is complete information, the problem still remains to understand the information, its character, its relevance, and the required methods to process the information. If there is incomplete information, people would have to rely on heuristics to bridge the lack of information, perhaps adding information, which is not available by assumptions biased by heuristic strategies like a tendency towards equal likelihood, or availability (Kahneman, Slovic, & Tversky, 1982), or by personal qualitative experience (singly in the past, success or failure recently). They might ask experts or counsellors who have their own interests who therefore might try to influence information and decisions to their advantage. Another human way out of the situation is to look at friends, peers, etc and find out what they do, or to look at the masses, or what media report etc (herd instinct). A hype may be fabricated by an opinion leader, or by repetitive reports in the media and influence the personal decision.

Psychological factors might influence the decision like: a tendency to avoid being responsible for the decision; lack of self confidence and being prone to the influence of counsellors who are pushing their interests; personal confidence gained in the person giving advice; other benefits from the relation to the counsellor (e.g. a beautiful lady counsellor); past experience: success or failure (also of friends); very memorable bad events still vivid from old times (inducing bad feelings one wants to avoid); development of external situation: steady rise or fall, or abrupt rise or fall of stock prices (inducing greed or fear, which blurs the insight); confusion about short-term and long-term consequences.

Risk management and improved decisions

The usual approach of rationality strives for a unique theory (of physics, such as the big bang, for explaining the whole 'universe'; one theory of statistics – either classical, or Bayesian (therefore the fierce debate on the foundations); one theory of mathematics (even at the price of losing the holy property of being 'free of contradiction'). If there is rationality – it is unique? The consequence of such a vision of rationality is to strive for a unique model implying one solution only. Better models are more refined, or more sophisticated, embedding the cruder model as a special case. Modern approaches use simulation to analyse this best model and blurs the discrepancy between model and reality even more – as it produces data on the basis 'as if'. However, such data acquire their own life and are interpreted without the restriction of the model as if they were real.

Two or more different valid models in parallel may actually fit the needs of the different parties involved much better. Strategies to improve comprehension of such modelling, and to improve the ways to deal with such a modelling approach have to be developed. The question remains as to find a way to embody theoretical concepts to make them more easily accessible without losing too much of their original meaning. Decisions involve many psychological factors: fear and hope; inertia; self-responsibility or a tendency to outsource responsibility. The ingredients are multi-faceted. Some people want to decide on their own – some people want to let others decide for them to avoid liability, whilst some want to decide for others for their own reasons (such as usurping power, or to be perceived as being helpful). We would argue that risk management has to include all parties – the approach has to be better than a unique meta-model with one final view: the final decision might mirror an 'informed decision' of the individual, which is respected and supported by the system, and which improves the system's state. Specific ideas for this approach are found in Pratt et al (1996) and Thaler & Sunstein (2008).

ABSTRACT

A situation of uncertainty involves a set of potential outcomes, which have a probability and an impact (loss or benefit). Personal behaviour varies a lot in everyday situations and reacts very sensitively to the setting of the situation. Even when the impact and probability are identical for a set of events – with the only exception that in one example the impact is a benefit and in the other example it amounts to a loss – the action preferred by people can differ radically, as shown by psychologists. Apart from the constructed artificial model of a situation, for people many more ingredients govern situations under uncertainty: the degree of small or large probabilities, the highest benefit or loss, other people's actions. This links to heuristics, constructed by development psychologists.

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