Chapter 3

Overweighting versus underweighting of small probabilities

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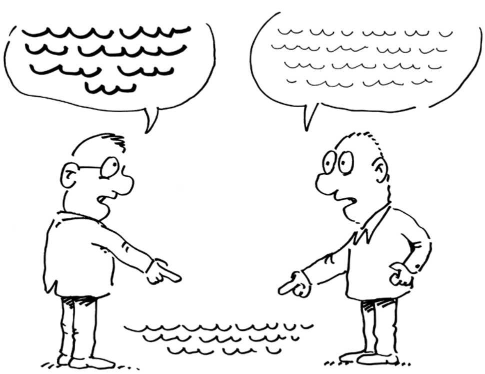
3.1 UNDERWEIGHTING AND OVERWEIGHTING OF SMALL PROBABILITIES



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There are many situations which require people to deal with low probability high consequence events, like earthquakes, floods, terrorism or natural disasters. The growing literature on this subject suggests that people have particular difficulty in the processing of these small probabilities (Magat *et al.* 1987; Taleb, 2007; Burns *et al.* 2010). Even experts often disagree about potential outcomes and chances connected with such situations (Mandl & Lathrop, 1982). Moreover, a perception of low probability high consequence events may be biased by affective evaluations (Schwarz & Clore, 1983; Forgas & Bower, 1987). In fact, we often observe inconsistent behavior in these situations. On the one hand, many people are willing to pay inexplicably large amounts to avoid risky events (e.g., McClelland *et al.* 1990). On the other hand, many just ignore such risks and want to pay nothing for decreasing the level of risk (Kunreuther *et al.* 1978).

Consider the following behavior: Andrew lives in a flood area in a house worth 1,000,000 USD. Large flooding occurs on average once in 1000 years in this area. To protect himself and his wealth, Andrew has an opportunity to buy an insurance policy with an annual cost less than 100 USD. However, despite the advice of his good friend who is an insurer, Andrew refuses to buy protection. On the other hand, every time Andrew plans a trip he buys additional insurance against terrorist attack, like plane hijacking or bomb attack. Such insurance with 50,000 USD benefits costs about 50 USD for a one month trip. Even in France which is the most exposed country to terrorist attacks in Europe, the probability that Andrew might be killed in a terrorist attack is extremely low – in the last two years there were less than 300 killed in terrorist attacks out of about 66 million people in France. This gives a 27 times lower probability than that of dying in a car accident (http://www.independent.co.uk, 2016). Is there anything unusual in Andrew's insurance decisions? According to the rational decision rule his behavior is inconsistent. Andrew seems to both overweight small probabilities (buying terrorist attack insurance) and underweight small probabilities (not buying flood insurance).

What is overweighting and underweighting of small probabilities? By the overweighting of small probabilities, we mean attributing to small probabilities higher weights than those predicted by normative decision theories. In other words, when small probabilities are overweighted, probabilities impact decisions more than is normatively appropriate. On the other hand, by the underweighting of small probabilities we understand there are situations when people do not pay much attention to probabilities and neglect them. Thus, probabilities impact decisions less than is normatively appropriate. Furthermore, in extreme situations probabilities might be even entirely ignored and be omitted in the decision-making process.

An excellent example of overweighting small probabilities is a situation described by Gigerenzer (2006). After the terrorist attack on September 11, 2001 where almost 3000 people died, because of higher level of fear a lot of Americans decided to reduce their air travel and instead drove by car. In the three months after the attack, passenger miles at the US national lines decreased respectively by 20%, 17% and 12%. As Gigerenzer (2006) estimated such a switch from flying towards driving resulted in an additional 1595 deaths for the 12 months following the attack. As Gigerenzer (2006, p. 350) noticed: 'This estimate is six times higher than the total number of passengers (256) who died in the four fatal flights.' This example describes how overweighting small probabilities may lead to irrational decisions and fatal consequences (i.e., choosing objectively more risky solutions which are, however, perceived as safer).

On the other hand, good examples of underweighting small probabilities are decisions not to buy insurance against floods, hurricanes or other disasters (even if it is subsidized). In these situations people feel that the probability of disaster is so low that '*it won't happen to me*'. In such situations people avoid buying insurance even when the expected value of it is positive and is explicitly stated (Kunreuther *et al.* 1998).

Why are highly unlikely events either neglected or overweighted? There are studies showing that this may be due to individual differences, with different people reacting in opposite ways in the same decision situation. For instance, McClelland *et al.* (1993) asked people about their willingness to insure against loss of money at different levels of probability. They found that people tend to behave in a bimodal way: some participants will pay even more than the expected value of an option while others will bid zero for insurance. Similar results were found in a study by Kunreuther *et al.* (1988), which found that, when asked about the riskiness of a proposed high-level nuclear waste repository, some people gave the extreme answer 'not at all serious' (16%), while others gave the answer 'very serious' (21%). McClelland and colleagues argued that this pattern might result from people's tendency to reduce the anxiety associated with uncertainty. When facing uncertain situations people might use two opposite strategies to cope with anxiety. One is to underweight the level of risk, thereby making the risk seem so small that a choice is perceived as safe. The other is to overweight probabilities, resulting in a choice being perceived as highly risky and thus one to be avoided (Slovic *et al.* 1981). But explanations are not limited to individual differences. Loewenstein and Mather (1990) noticed that people tend to apply different types of reasoning in the case of counter-terrorism efforts than in the case of the prevention of natural disasters. The former seem to be over-financed compared to the latter, which are under-financed (www.bigthink.com). The authors describe this pattern of behavior as overshooting versus undershooting an appropriate level of riskiness.

Kahneman and Tversky (1979, p. 283) conclude the same point as follows:

> *Because people are limited in their ability to comprehend and evaluate extreme probabilities, highly unlikely events are either neglected or overweighted, and the difference between high probability and certainty is either neglected or exaggerated. Thus, small probabilities generate unpredictable behavior. Indeed, we observe two opposite reactions to small probabilities.*

In next sections, we will focus on the mechanisms of overweighting and underweighting small probabilities.

3.2 WHEN DO PEOPLE TEND TO OVERWEIGHT SMALL PROBABILITIES?

People's tendency to overweight small probabilities is a robust finding which has support in prospect theory (Kahneman & Tversky, 1979) and in empirical studies (e.g., Tversky & Kahneman, 1992; Wu & Gonzalez, 1999). Authors of prospect theory assume that people weight probabilities subjectively, and, as we see in Figure 3.1, the weights don't need to be linear with respect to objective probabilities. In particular, the small probabilities are overweighted.

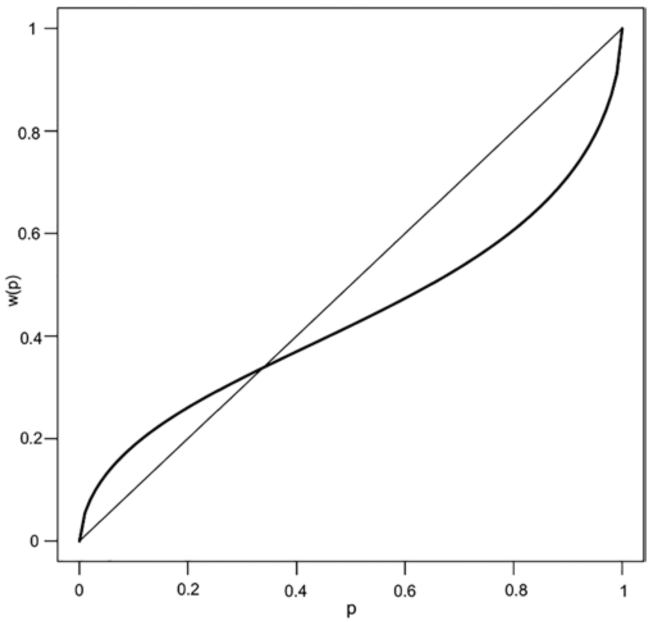

Figure 3.1 The inverse Kahneman-Tversky S-shape probability weighting function where small probabilities are overweighted and medium and large probabilities are underweighted. The identity line indicates linear weighting – no transformation of objective probabilities.

An interesting observation about the overweighting of small probabilities was made by Kunreuther and Pauly (2005), who noticed that after the attacks of September 11, 2001 (9/11) insurers started to offer protection in case of terrorism only at very high prices (and sometimes it was not possible to find a seller who would offer such insurance at any price). However, before 9/11, terrorism was mostly included in the 'all perils' policy form, which meant that insurers perceived the risks connected with car accidents and terrorism attack as the same. After that, in just one moment, formerly ignored terrorism started to be so heavily overweighted that insurers decided to make fundamental changes on how it was categorized. Another example of overweighting of small probabilities is willingness to buy lottery tickets. According to normative theories (e.g., expected utility), people should not buy lottery tickets because of the negative expected value of the gamble. However, as probably most of us know, there are a lot of people who participate in lottery games.

One of the main psychological biases which influences the way people weight probabilities is diminishing sensitivity. Diminishing sensitivity implies that increasing distance from the reference points (in the case of probability there are two natural reference points: 0% chance which is impossibility and 100% chance which is certainty) diminishes the subjective impact of a change in probability. In other words, any change next to the reference points (i.e., from 0% chance to 1% chance) looms larger than any change in the middle of the scale (i.e., 50% chance to 51% chance). Indeed, Tversky and Kahneman revealed that a median participant in their study was indifferent between receiving a lottery ticket which gave a 1% chance to win \$200 and receiving \$10 for sure. On the other hand, when asked about the certainty equivalent for a lottery ticket which gave a 99% chance to win \$200, the assessed amount was \$188. Thus, the first percent of probability was priced at \$10 and the last one at \$12. However, the other 98% was worth \$178, which means about \$1.82 for each percent on average. Those large jumps next to the reference points imply that small probabilities are in this case overweighted and large probabilities are underweighted.

Another explanation of the overweighting of small probabilities is proposed by Rottenstreich and Hsee (2001) – the affective deconstruction of the probability weighting function. The affective approach is based on an assumption of the occurrence of hope and fear, which explain the overweighting of small probabilities and underweighting of large probabilities. A change of probability from impossibility to possibility creates a situation in which some hope exists, in contrast to the situation where the probability of winning is equal to zero. A similar pattern is observed with regard to the right-hand side of the probability weighting function – when the probability of winning is lower than 1 – that is, the chance of winning is 99% – some fear exists. As Rottenstreich and Hsee (2001, p. 185) conclude: '… the affective approach holds that the jumps in the weighting function can be attributed, at least in part, to the affective reactions – which we label hope and fear – associated with a lottery.' As they suggest, the greater the affect the larger the jumps in both sides of the probability weighting function. Thus, there is more overweighting of small probabilities for an affect-rich subject (i.e., a 'short, painful, but not dangerous electric shock.' (p. 188)) than for an affect-poor one (i.e., a \$20 cash penalty).

Emotional reactions may also influence situations when the chance of occurrence is extremely low but the consequences are large; in such cases, people focus solely on losses rather than interaction between potential losses and probability (Ganderton *et al.* 2000). As a perfect example, we can present following quotation: 'After the attacks on 9/11, considering the possibility that al-Qaeda wanted to acquire a nuclear weapon, Vice President of the United States Dick Cheney remarked that (Suskind, 2006; p. 62),

> *We (America) have to deal with this new type of threat… a low-probability, high-impact event… If there's a 1% chance that Pakistani scientists are helping al-Qaeda build or develop a nuclear weapon, we have to treat it as a certainty in terms of our response. It's not about our analysis. It's about our response.*

Such situations, when we want to avoid the peril at any price, lead us to extreme overweighting of small probabilities.

We can observe that the occurrence of the overweighting of small probabilities may depend on a few factors like: (1) distance from reference points, for example we will overweight probabilities more heavily in situations when the chance of flood occurrence will increase from 0% to 1% than from 5% to 6%; (2) the level of emotional connotations; namely, we tend to overweight probabilities more heavily when the object of interest induces higher emotional reactions, and (3) the higher the perceived level of potential losses (or in other words more extreme negative outcomes), the greater the tendency to overweight small probabilities, for example if we can lose our entire wealth in a flood we will overweight the probability heavily and do everything to protect ourselves.

3.3 WHEN DO PEOPLE UNDERWEIGHT SMALL PROBABILITIES?

Numerous evidence of the underweighting of small probabilities can be found in the domain of insurance studies (e.g., Kunreuther *et al.* 1978; McClelland *et al.* 1990; Botzen *et al.* 2015). Those studies show that people tend to neglect some types of threats (like natural hazards, car accidents) and behave as if the risk does not exist (e.g., do not buy insurance or drive without seatbelts). Moreover, as Kunreuther (1978) revealed, people sometimes fail to protect themselves even when it is subsidized (e.g., not purchasing subsidized insurance). Such patterns of behavior may expose societies to very high potential losses in extreme situations. Also, studies in other domains have indicated that people tend to underweight small probabilities. For example, Oberholzer-Gee and Frey (1998) revealed that inhabitants of areas which are potential sites for nuclear waste facilities tend to ignore the risk associated with the potential hazard.

Risky decisions are based on two components – the potential outcome and the probability of occurrence (Weber & Milliman, 1997). However, as Slovic and colleagues (1977) noticed, in the domain of insurance we encounter situations where people focus just on one factor. Thus, if people focus only on the probability, they may act according to the threshold model, which assumes that people ignore risks if their subjective probability is below a certain level of concern (Slovic *et al.* 1977). Hence, people may behave in the following way: '*if the probability is above* *my threshold level of concern I take an action, if not I just neglect it*' (Botzen *et al.* 2015). In the case of a small probability event, people might think that it is unlikely to happen and do not pay any attention to it. The probability itself might be below the individual's perception threshold (Ganderton *et al.* 2000) evoking a belief that 'it won't happen to me'.

Other possible explanations why people neglect small probabilities and do not buy insurance, for example, emerge from the research of Kunreuther *et al.* (2001). Their study showed that people are unable to understand the probability context. Individuals do not distinguish low levels of probability (e.g., 0.00001 or 0.000001) if they do not possess additional information about the riskiness of a situation. More precisely, to estimate properly the probability of a negative outcome people need fairly rich context information – the more useful it is, the better the probabilities are evaluated (Kunreuther *et al.* 2001). For example, if we want to properly interpret the risk associated with a 1-in-1000-year flood we need to have comparisons of better known examples which are easier to imagine. We need to show that the level of risk of a 1-in-1000-year flood is equal, for example, to the level of risk associated with a car crash while driving a car in mountains during a snowstorm. Such a reference point helps to properly evaluate the level of risk. On the other hand, if people do not have any additional information or reference point, they are unable to understand small probabilities and ignore some of them.

Another explanation for why people underweight small probabilities was presented by Kunreuther and Pauly (2004). As the authors claim, people sometimes fail to buy insurance because of the search costs associated with purchasing it. More precisely, if the cost of collecting information about the threat (i.e., the probability distribution of outcomes) is very high, it may discourage people from obtaining and processing the data. Thus, people do not search for objective information and do not buy insurance. As Kunreuther and Pauly (2004) notice, this process of decision-making is consistent with the bounded rationality hypothesis. Namely, if we do not perceive the initial level of probability as being sufficiently high to exceed some threshold level, we will not make an effort in time and energy to collect and process the data connected with probability. In other words, we might decide to ignore small probabilities because of the high costs of searching for the information needed to understand the probability.

To sum up, the underweighting of small probabilities may occur in a few situations: (1) when people focus solely on the probabilities (instead of the interaction of the probabilities and potential outcomes) and the level of probability does not exceed the threshold level; (2) when people do not have enough information to understand the probability and do not have a reference point in order to compare an unfamiliar risky situation to one which is well known, and (3) when cost of obtaining rational information about the probabilities is perceived as too high and people give up acquiring information.

So far, we have described two opposite reactions to small probabilities – overweighting and underweighting – and circumstances surrounding both.

Behavioral decision research has been dominated by the view that people generally tend to overweight the probability of a rare event (Starmer, 2000). However, some researchers raise the issue of ignoring the low probabilities of catastrophic events, leading to insufficient protective behavior or a lack of insurance against the negative consequences of such events (Kunreuther, 1996; Lamond *et al.* 2009). Perhaps the explanation of these phenomena lies in the manner by which people learn about probabilities and the outcomes of risky events. It seems that people often consider low probability/high impact events (e.g., natural hazards) based on their experience rather than on the use of statistical information (Burningham *et al.* 2008). In the next part, we describe the differences between two sources of information about rare events, that is, when decisions are based on descriptions or on experiences, and we show their influence on dealing with low probabilities.

3.4 'DECISIONS FROM DESCRIPTION' VERSUS 'DECISIONS FROM EXPERIENCE'

Let us consider two situations described in ask.metafilter.com:

> *A young couple thinks about moving from a small town to Portland, which is affordable for them, progressive, and has a great balance between beautiful outdoor countryside and the community of a larger city. They do research and discover the Cascadia Subduction Zone. Depending on what article they read, the chances of a 9.0 earthquake in Portland within the next 50 years is 10%–60%. As they have said: 'they don't feel great about moving forward with a plan that puts them so clearly in danger'.*
>
> *A resident responds to them that he 'has lived in the Portland area for 38 years, and the largest earthquake he has experienced was about a 5.5.' He advises them to not worry and to not abandon their moving plans.*

The above addresses the two categories of decision situations. The first applies when people choose between options with explicitly given information about probabilities and outcomes. In this case, people make 'decisions from description' (Hertwig *et al.* 2004). This kind of decision is analyzed by prospect theory and was mostly considered in traditional research on decisions under risk (e.g., Starmer, 2000; Fox & Poldrack, 2014).

The second applies to situations when people do not have a description about risky options. Indeed, people outside a laboratory rarely have an opportunity to know probabilities of rare events a priori. They often formulate their opinions and make decisions on their own experiences and observations. In such situations, when decision-makers learn about a distribution of risky outcomes through some sort of sampling, they make 'decisions from experience' (Hertwig *et al.* 2004).

In a research lab, respondents make decisions by description by choosing between two options (usually lotteries) with numerically described probabilities and payoffs. For example, they have to choose between a $100 loss with probability

1% or a certain loss of $10. For decisions from experience, the most popular way of simulating the experience is a *sampling procedure* (Hertwig *et al.* 2004). Respondents see on a computer screen two buttons. Each button represents an option (a lottery) with distribution of outcomes unknown to the respondent. In the first stage respondents click on one of the two buttons and sample (observe) the outcomes, which are randomly generated depending on the option associated with the button. For example, when a respondent clicks on the button assigned to a $100 loss with probability 1% or $0 otherwise, then two payoffs can be displayed on the computer screen: a loss of $100 or $0. Respondents can click on the two buttons as many times as they want and observe the consequences of choosing each one of the buttons. In the second stage, when respondents feel confident enough that they are familiar with the options, they make a final choice.

Figure 3.2 facilitates understanding of the experimental procedures used in decisions from description and decisions from experience. Both part (a) and part (b) represent the same problem. In a decision from description (Figure 3.2. (a)), a typical task consists of two options with numerically described probabilities and payoffs. In a decision from experience (Figure 3.2. (b)), a typical task consists of two stages. In Stage 1 (represented here by seven fictitious draws) a person explores two options by clicking on one of two buttons on a computer screen. In each trial, the button chosen by a participant displays a payoff which is randomly generated depending on the option associated with the selected button. In the illustration below, the left button represents a loss of $100 with probability 0.01 and 0 otherwise, and the right button represents a certain loss of $10. In the first trial, a participant has selected the left button and received a 0 outcome. In the second trial, the participant has selected the right button and received a −$10 outcome, etc. The participant has terminated sampling with the two buttons after seven trials. In a choice stage (Stage 2), after being acquainted with the nature of both options, the person is asked to select a left or right button to draw once for real. In the example below the respondent has chosen the left button and received a final outcome of 0.

Hertwig *et al.* (2004) used this sampling procedure and found significant differences in risky choices between description and experience conditions across six decision problems involving rare events. Participants considered each problem having two options with the same expected value. In the description condition, participants most often preferred a larger rare gain over a smaller certain one and simultaneously preferred a smaller certain loss over a larger rare one. Such preferences are predicted by prospect theory and are congruent with the idea of overweighting small probabilities. The opposite tendency emerges when decisions from experience were considered: people preferred a smaller certain gain over the larger rare one and simultaneously selected the larger rare loss over the smaller safe one. These preferences were in opposition to the prediction of prospect theory and revealed the underweighting of small probabilities. Similar results were replicated in other studies (e.g., Hau *et al.* 2008; Rakow *et al.* 2008; Ungemach *et al.* 2009).

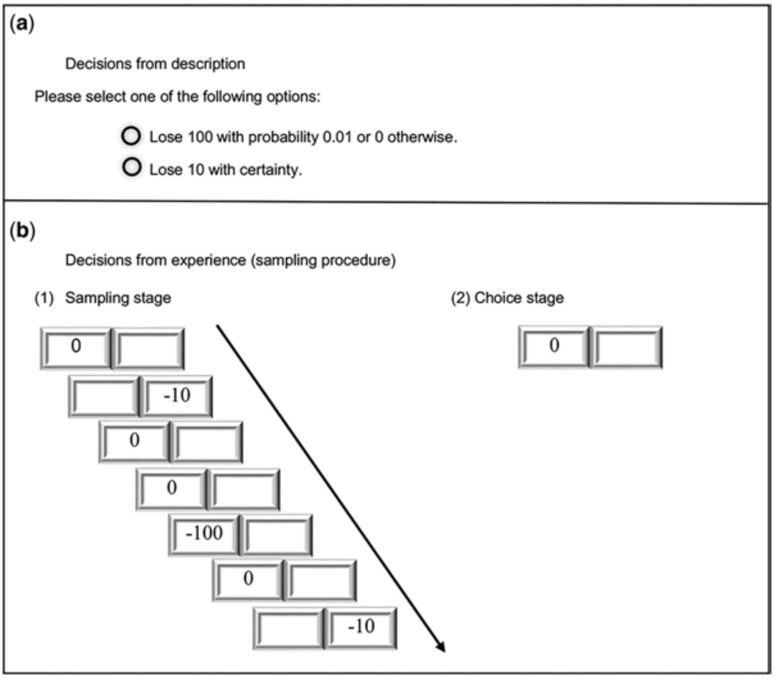

Figure 3.2 Schemes for decisions from description and decisions from experience (sampling procedure).

In decisions from description, people tend to overweight small probabilities, whereas the opposite bias appears in decisions from experience, when people tend to underweight small probabilities (Hertwig & Erev, 2009; Rakow & Newell, 2010). These experimental results seem to be supported by real life situations. Kreibich *et al.* (2005) interviewed almost 1200 households affected by the 2002 flood of the river Elbe and its tributaries. They found that almost 60% of these households stated that they did not know that they lived in a flood zone, and only 6% of the households had flood-adapted building structures. This provides an instructive picture of the underestimation of flooding probabilities, which is likely to have been based on experience rather than description. The disparity in preferences between decisions from description and decisions from experience was called *the description-experience gap.* Its magnitude is measured by the difference in number of risky choices congruent with prospect theory in description and experience conditions.

Researchers have tried to explain the description-experience gap and thereby explain why in some situations people overweight small probabilities and in other situations they underweight them. Understanding the mechanism of the description-experience gap can be insightful in explaining humans' responses to rare, catastrophic events.

3.5 EXPLANATIONS OF THE DESCRIPTION–EXPERIENCE GAP

In the following section we will present mechanisms underlying the description-experience gap. In particular, we will focus on three factors which cause underweighting of low probabilities: sampling bias, switching behavior, and recency effect, in the experience condition, and one factor – mere-presentation effect – which causes overweighting in the description condition.

3.5.1 Sampling bias

One of the key determinants of the underweighting of small probabilities in experience-based decisions is a *sampling bias,* which occurs because people rely on *small samples* (Hertwig *et al.* 2004). The sampling bias is experimentally illustrated in the sampling procedure. People first observe unknown payoff distributions of two buttons and after that make a single choice. Moreover, people can decide how long they want to observe the series of outcomes of each option (Hertwig *et al.* 2004). Hau *et al.* (2010) noticed in a number of experiments that the median number of observations people wanted to see did not exceed 20. Such a small size of sample did not allow for an adequate representation of rare events. Participants obtained a somewhat skewed binomial distribution of outcomes, in which rare events were underrepresented. The smaller the sample the more probable that respondents observed a relatively lower number of rare events than the objective probability. Some subjects did not see any at all. Consequently, they tended to underweight or ignore rare events.

Hadar and Fox (2009) claimed that a decision-maker understands distributions of outcomes in experience conditions differently than in description conditions. Thus, the description-experience gap should disappear when the information about probabilities and outcomes of the risky option is equivalent in both conditions. Thus, the sampling error occurring during the experience procedure is responsible for biasing the information about the probabilities. Research showed that delivering a larger sample size reduced the experience-description gap but did not eliminate it completely (Hau *et al.* 2008; Camilleri & Newell, 2009; Ungemach *et al.* 2009; Hau *et al.* 2010). Even if people have an opportunity to fully experience the frequency of a rare event, they tend to underweight its small probability.

The degree of the underweighting of small probabilities in decisions made from experience depends on the sample size: the larger the sample the smaller the sampling bias and the weaker the underweighting of small probabilities in the experience condition. Sampling bias is a significant determinant of the underweighting of small probabilities not only in experiments but also in real life situations. People usually have limited experiences of rare events and might never observe them during their lifetimes. Thus we can observe, for example, the limited concern about climate change and its consequences, because as Weber (2006, p. 103) suggested: ‘Personal experience with noticeable and serious consequences of global warming is still rare in many regions of the world.’

3.5.2 Switching behavior

> *In the year 1611, Barbara, first wife of the imperial mathematician and court astronomer Johannes Kepler, died of cholera in Prague. Kepler, widower and father of two, immediately began a methodical quest for a replacement. He considered 11 candidates, eventually choosing Susanna Reuttinger, who, he wrote, 'won me over with love, humble loyalty, economy of household, diligence, and the love she gave the stepchildren' (Connor, 2004; p. 252). Although we do not know how he inspected the 11 candidates, several search strategies are possible: Antedating modern online dating strategies, he could have chatted with each of them on alternate days over a period of months, recording whom he liked most over each series of 11 days. Alternatively, he could have spent weeks at a time with each candidate, making summary assessments of each.*
>
> *Although both search strategies could uncover the same information, the choices that follow from them would not necessarily be the same. The first strategy might have led Kepler to choose the person who was better in more of the 11-day bouts than any other candidate. The second strategy, in contrast, might have led him to choose a partner whose long-term mate value turned out to be best. This could have been a person who was not the best companion on many days of the year but who greatly surpassed any competitor on a few days. This divergence in the final decision highlights an important possibility: Specific sequential search strategies employed in making a choice could be coupled with specific decision strategies employed to render the final decision.* (Hills & Hertwig, 2010; p. 1)

Hills and Hertwig (2010) in their empirical research showed that not only small sample size but also sampling strategy increases underweighting of small probabilities. They noticed that experiment participants can be classified as either 'frequent switchers' that is, those who switched frequently between two options they observed, or 'infrequent switchers' – who kept to one option before then switching to the other.

However, the effect of frequent switching between options in the sampling period is to divide a sample into a few subsamples and compare the results of the different options over a few rounds. The option which 'wins' the most rounds is preferred. People who do not switch between options take the average of the outcomes of each option and then maximize the average. The infrequent-switchers strategy does not lead to underweighting. The frequent-switchers strategy leads to underweighting of rare events in the experience condition and consequently enlarges the magnitude of the description-experience gap. Thus, in order to force people not to ignore rare, catastrophic events, they should be encouraged to observe a long series of outcomes for one option rather than to collect subsamples. In order to choose a safe residence it is better to carefully scrutinize the flood history of one place and then that of the other rather than switch from one place to another in analyzing past years.

3.5.3 The recency effect

The recency effect is another factor, which can help to understand the underweighting of small probabilities in decisions from experience. The outcomes which a participant observes towards the end of a sequence of events seem to have a greater impact than the outcomes from the beginning of the sequence. Rare events under experience conditions can have a smaller impact on decisions than they should have on the basis of objective probability, because a rare event has a small chance of appearing at the end of the sequence of sampled outcomes. Hertwig *et al.* (2004) divided samples into early experienced and recently experienced events. They report that the second part of a sample had a stronger predicted power than the first half, a finding which indicates a recency effect.

However, other researchers found the impact of the recency effect on final choices as not being significant (Hau *et al.* 2008; Ungemach *et al.* 2009; Camilleri & Newell, 2011) or being quite limited (Rakow *et al.* 2008).

Although the contribution of the recency effect to the underweighting of probabilities of rare events in decisions from experience was not strongly supported in empirical studies it is hard to deny that recent events can significantly influence the reaction to rare hazards.

3.5.4 The mere-presentation effect

The three factors mentioned so far as being responsible for underweighting small probabilities concerned decisions from experience. The mere-presentation effect is responsible for overweighting small probabilities in decisions from description.

Erev *et al.* (2008) noticed that outcomes with small probabilities are weighted more strongly in a decision from description than in a decision from experience simply because of their mere presentation to the decision-maker. This so-called mere-presentation effect means that in the decision from description, both outcomes of a risky option (e.g., one outcome with a small and one outcome with a large probability) are weighted more equally than they should be according to their objective values of probabilities by both being present in a subject's mind. And if a rare event exists in somebody's mind, then its psychological impact increases in the decision-making process. Teoderescu and colleagues (2013) compared the mere-presentation effect to 'a white bear effect'. If people are requested to 'not think of a white bear,' then it is very hard to ignore the sentence, and it captures and holds people's attention. A rare event in the description condition has the similar effect. Even if people know that its probability is very low, they pay relatively too much attention to the outcome associated with this probability.

In the experiments with the sampling procedure respondents sample outcomes of risky options without initially knowing how many different payoffs they would experience. In contrast to the decisions from description, the rare events are not merely presented to a decision-maker in the decision from experience. Erev *et al.*

(2008) showed that explicitly presenting the outcomes of risky options in the sampling procedure increased the impact of those unlikely events on choices. The mere presentation of the rare event in the decision from experience mode can weaken the tendency towards underweighting small probabilities and diminish the description–experience gap.

3.6 THE PROBABILITY WEIGHTING FUNCTION: HOW TO COMMUNICATE PROBABILITIES

The distinction between 'decisions from description' and 'decisions from experience' poses a question regarding which method of communicating probabilistic information would be the most comprehensible by ordinary people. A full answer to this question will be addressed in the next chapter. Now, referring to the probability weighting function described in prospect theory (Kahneman & Tversky, 1992), we very briefly review research on the shape of this function when it is derived from decisions from description and from decisions from experience.

The shape of this function presented in Figure 3.1 was widely confirmed in decisions from description when probabilities were explicitly given (Starmer, 2000; Wakker, 2010). The question is what happens to this shape in decisions from experience. Hau *et al.* (2008) conducted an experiment and estimated the parameters of the probability weighting function for experienced frequencies. Their curve of the probability weighting functions turned out to be very close to the identity line. These results indicated a linear weighting of experienced probabilities (see Figure 3.3).

In turn, in an experiment by Abdellaoui *et al.* (2011), the probability weighting function for the experience condition had the same curvature as in the descriptive condition, although it was not as elevated as for decisions from description. In effect, small probabilities were overweighted both in decisions from description and in decisions from experience, but the overweighting was less pronounced for experienced probabilities. Thus, at least in relation to small probabilities, the weights obtained for decisions from experience were closer to objective probabilities. This could imply either that the experienced probabilities are linearly weighted or that the weights for experienced probabilities are lower in decisions from experience than in decisions from description.

Some researchers claim that when choosing among risky options, individuals may use strategies which do not require representations of probability at all (Hau *et al.* 2008; Erev *et al.* 2010; Hertwig, 2012). For example, they may apply the natural-mean heuristic rule, according to which an individual observes and averages outcomes over the sample and chooses the option with the larger mean. According to another heuristic – the maximax rule – an individual chooses the option with the higher experienced maximum outcome. The problem with such rules is that while they may describe well preferences in the sense of predicted behavior, this does not mean that they describe well the processes which are used in decision-making (Glöckner *et al.* 2016). In particular, they do not resolve the question of using the probability representation in the decision process when choices are based on experience.

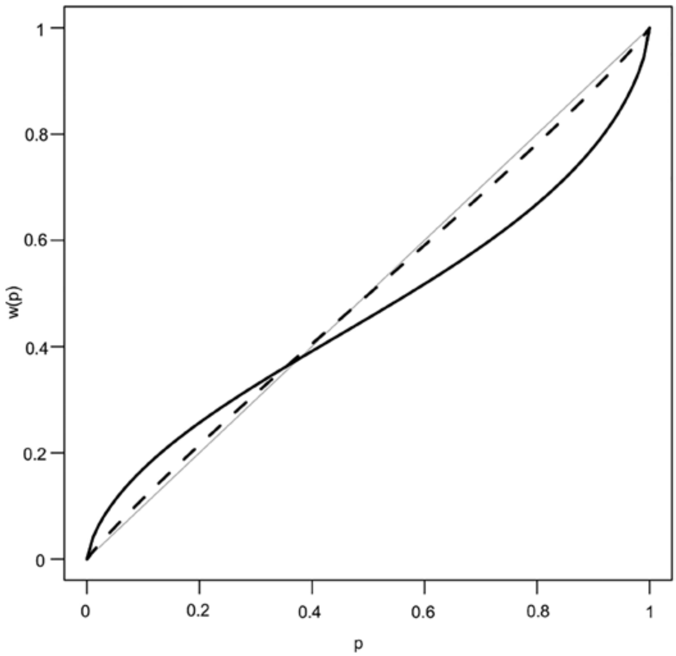

Figure 3.3 Probability weighting functions for decisions from description and decisions from experience. The solid line represents the probability weighting function estimated from Tversky and Kahneman (1992) and the dotted line represents the experienced frequency weighting function estimated from Hau *et al.* (2008).

3.7 CONCLUSIONS

People face considerable difficulty when dealing with probabilities in general and with small probabilities in particular. They reveal two contradictory tendencies regarding small probabilities: sometimes they overweight them and at other times they underweight or completely ignore them. The tendency to overweight small probabilities may come from diminishing sensitivity with increasing distance from the reference points, that is, from impossibility (0% chance) and certainty (100% chance). Another reason for overweighting small probabilities may be over-exaggerated emotional reactions to actual or potential losses. On the other hand, small probabilities can be underweighted. This happens first of all when probabilities are perceived below some threshold level. As it is well known, a typical driver does not bother about the hazards associated with driving an automobile every morning.

Similarly, inhabitants of flood prone areas may think that the risk of living there is negligible. It makes sense that policymakers remind those living in such areas that they are not completely safe. This underweighting of small probabilities in the case of natural hazards such as floods is particularly undesirable behavior. It may lead to insufficient efforts to reduce flood risk or to entirely ignoring the need to protect oneself against consequences of catastrophic risk.

Research shows that an important factor determining the perceptions of probabilities is the source of the information about probabilities. When small probabilities are explicitly given to a decision-maker, people generally over-respond to them. But when small probabilities are experienced through sampling processes, the reactions are opposite: people underreact to small probabilities. This suggests that when people underweight or completely ignore the probability of a disaster, and we want to make them more attentive to the disaster, we should present probabilities to them in a descriptive way. Such practices are sometimes implemented on roads to discourage drivers from speeding, with billboards in dangerous places showing the number of fatal and other accidents. It would be useful to follow similar practices when warning about floods and other natural disasters.

On the other hand, when people overweight the probability of disaster (for example due to emotions) and we want to reduce their fears of a disaster, then we should present probabilities to them using a sort of simulation of negative events. The detailed procedure is shown in the next chapter.

In the case of natural hazards people should also be aware of traps related to decisions from experience. A common trap of this kind is that when there has been a long flood-free period, inhabitants of endangered land begin to neglect the hazard. This is the recency effect. In such a situation a policymaker could provide them with historical data on the risk of flooding. Moreover, the recency effect can be intentionally used in order to maintain people's attention on particular issues. After a flood, the recency effect may be helpful for inducing protective activities among the affected people, which will diminish the negative consequences of future disasters.

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