"It won't happen to me": Review of basic and applied studies of the impact of rare events

Chapter forthcoming in Vicki Bier (editor), The Gower Handbook of Extreme Risks. Farnham, UK: Gower

Eyal Ert, Environmental Economics and Management, The Hebrew University of Jerusalem
Ido Erev, Max Wertheimer Minerva center for Cognitive studies, Technion

Abstract

Studies of decisions from experience reveal that in many cases the decision maker tends to underweight rare events, and behave "as if" she believes that "it won't happen to me." The current chapter begins with a review of previous experimental studies that demonstrate the robustness of this phenomenon. It continues with evaluating the boundary conditions and the processes that underlie the "it won't happen to me" effect. In essence, this effect can be captured with the assumption that the propensity to select a specific option is a function of two terms: The mean payoff provided by that option over all previous trials, and the mean payoff from that option in a small sample of past experiences. The chapter concludes with empirical demonstrations of the implications of the "it won't happen to me" effect to the behavioral impact of extreme risks.

Keywords: Experience-description gap; sampling; uncertainty; descriptive models

This research was supported by grants from the Israel Science Foundation.

Many life activities imply a participation in a gamble that involves rare events. Flying to another country might (rarely) result with a serious damage in case the plane crashes. Crossing a red light might also result with serious damage in case of an accident. So is speeding, not using safety devices, or living in areas that are susceptible to floods, earthquakes, or volcano eruptions. Other examples include, but are not limited to, sending a paper for publication in a high profile journal, investing money in new projects or in the stock market, buying products or services on the internet, engaging in unsafe sex, trying any medical drug that has some side effects, and the list goes on.

While the aforementioned activities are very different in many respects, they all share a common feature in that all of them involve rare events: outcomes (good or bad) that occur with a small probability. Another common feature of these activities is that the decision maker does not know a-priory the exact probabilities of these rare events. Instead, the decision maker has to learn the outcome distribution over time relying on his own, and/or on other people's experiences.

The classical study of human decision-making tried to address the natural decisions exemplified above by the distinction between judgment (estimating probability) and decision processes. Implicit in this two-process approach is the assumption that people first estimate the probabilities of the feasible outcomes, and then choose between the different options by weighting the outcomes by their estimated probabilities (see Fox & Tversky, 1998). Most previous studies focused on one of the two processes. Basic studies of human judgment processes have compared intuitive probability estimates to objective probabilities. An exemplar of these studies (Phillips & Edwards, 1966) is presented in the first row of Table 1. The typical results of these judgment studies suggest that people tend to overestimate small probabilities. Experimental studies of choice behavior have examined one shot choices in "decisions from description." The participants were asked to choose (once) between fully described payoff distributions. The typical results suggest that people tend to overweight the rare events. The second row in Table 1 summarizes one example of this observation.

Table 1: *Summary of experimental studies that demonstrate overestimation of small probabilities and overweighting of rare events (following Marchiori, Di Guida, & Erev, 2015)*

Typical experimental task	Typical results and interpretation
Judgment (Phillips & Edwards, 1966) Urn A includes 30 Red Balls and 70 White balls. Urn B includes 70 Red Balls and 30 White balls. One of the two urns was randomly selected (the prior probability that A would be selected is 0.5). The experimenter sampled with replacement 4 balls from that urn. All 4 balls are Red. What is the probability that the selected urn is A?	**Overestimation** Mean estimate: 0.23 Bayes' posterior probability: 0.01 The mean estimate of 0.23 reflects overestimation of the objective small probability (0.01).
Choice (Kahneman & Tversky, 1979) Choose between the following two options: Option S: -5 with certainty Option R: -5000 with probability of 0.001; 0 otherwise	**Overweighting** Choice rate of option R: 20%. This choice rate suggests that most subjects behave as if the probability of the rare event (-5000) is over-weighted.

The coexistence of overestimation of small probabilities and overweighting of rare events appears to suggest that people are likely to exhibit extreme oversensitivity to rare events in decisions under uncertainty. Surprisingly, however, recent research shows that the exact opposite is often correct. Studies of decisions in situations in which people can use past experience to estimate the relevant probabilities reveal a bias toward underweighting of rare events (Barron & Erev, 2003; Hertwig et al., 2004). The typical decision maker behaves as if experience leads him or her to believe that "it won't happen to me". The findings from this recent research suggest a "description –experience gap" (Hertwig and Erev, 2009): People tend to overestimate the probability of rare events when they are asked to estimate them, and overweight rare events when they response to a description of the potential risks. However, people tend to underweight rare events when they do not respond to descriptions of probabilities but rely instead on their own experiences.

The current chapter reviews and tries to clarify the study of experience on choice behavior. Sections 1-3 summarize experimental studies that examine the robustness of the "it won't happen to me" effect. Section 4 presents new experiments that compare alternative explanations for the observed bias. The results suggest that experience reduces the weighting of rare events, but does not lead to a complete neglect of these events. Section 5, which concludes the chapter, is designed for readers interested mainly in the managerial implications of this phenomenon for risk management. This section presents empirical demonstrations of some implications of the “it won’t happen to me” phenomenon to different domains of decisions under uncertainty that involve extreme risks.

1 Studies of repeated decisions from experience: The clicking paradigm

The clearest demonstrations of the "it won’t happen to me" effect come from studies that used variants of the “clicking paradigm.” The current section describes this paradigm and reviews the main experimental results.

1.1 The basic clicking paradigm

Barron and Erev (2003) used the basic *"clicking paradigm”* demonstrated in Figure 1. The figure presents its instructions and interface. The decision makers were asked to select between two unlabeled keys on the computer screen. Each click led to a random draw from the payoff distribution (realization of gamble) associated with the key that was clicked. The value drawn from the selected key determined the decision maker's payoff for that trial. The decision makers received no prior information concerning the relevant payoff distributions, and could only infer these distributions based on their obtained payoffs from previous choices.

Instructions	Pre choice	Post choice
The current experiment includes many trials. Your task, in each trial, is to click on one of the two keys presented on the screen. Each click will be followed by the presentation of your payoff from that click. Your final payoff will be determined by the payoff in one randomly selected trial.	Please select one of the two keys	Your payoff in this trial is 3. 3

Figure 1: The instructions and interface of a study that uses the basic clicking paradigm with partial feedback (Barron & Erev, 2003). In the example the subject chose Left and won 3. The exact payoffs were determined by the problem's payoff rule. For example, in Problem 1, each Left choice leads to a payoff of 3, and each Right choice leads to a payoff of 32 in 10% of the trials, and 0 in the other 90% of the trials. The assignment of prospects to buttons and the order of the problems were randomly determined for each subject.

Barron and Erev studies show that immediate feedback tends to move behavior toward maximization, but there are robust exceptions. One exception was documented in the study summarized in Figure 2.

Problem	Option S	Option R
BE1	3	(32, 0.1; 0)
BE2	-3	(-32, 0.1; 0)

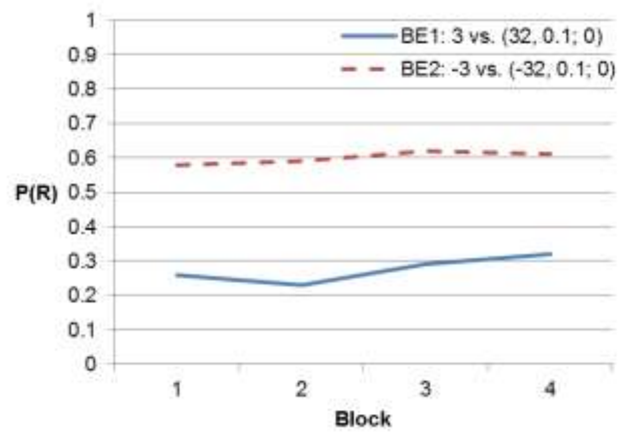

Figure 2. Problems BE1 and BE2 studied by Barron and Erev (2003). Problem BE1 involves a choice between 3 with certainty (Option S), and a gamble (32, 0.1; 0) that yields 32 with probability of 0.1 and 0 otherwise (i.e., with probability of 0.9; option R). Problem BE2 involves choice between loss of -3 (option S) and loss of -32 with probability 0.1. Subjects played each problem in the clicking paradigm for 400 trials. The Figure shows the propotion of choices in the riskier Option R (P(R)) in 4 blocks of 100 trials each.

Both decision problems were played for 400 trials with the clicking paradigm, and the payoffs were in Israeli Agorot (1 agora is 0.01 sheqel, and it was equal to about 1/4 US cent). In Problem BE1, one key (Option S) always led to a gain of 3, and the other key (Option R) led to a gain of 32 in 10% of the trials, and to a payoff of 0 in the other trials. The results revealed that the choice rate of the riskier option, which is associated with higher expected value (Option R, EV=3.2), dropped with experience. The maximization rate over the 400 trials was only 28%. Thus, the subjects learned to prefer the safe option even though it is associated with lower expected value.

In Problem BE2, one key (Option S) always led to a loss of 3, and the other key (Option R) led to a loss of 32 in 10% of the trials, and to a payoff of 0 in the other trials. The results revealed that in this problem the subjects learned to prefer the riskier option. Since the riskier option (Option R) has lower expected value (-3.2), the results implies large deviation from maximization in this problem as well. Experience led the subjects to prefer the low expected value risky prospect.

The results observed in both decision problems are consistent with the "it won't happen to me" effect: The typical choice reflects low sensitivity to the rare but large outcomes (+32, and -32). Erev and Barron (2005) note that this low sensitivity can be a product of a tendency to rely on a small set of past experiences. For example, if the subject relies on a sample of four past experiences with each option from their memory in Problem BE2, she will select option R 65.6% of the times (because 65.6% of the samples of size 4 do not include the realization of the rare event).

1.2 Clicking with full feedback: exposure to "forgone payoff"

Subjects in Barron and Erev (2003) studies received "partial feedback:" only their selected option was realized after each choice. Studies that relax this constraint and used the clicking paradigm with "full feedback" after each trial, which includes information on "forgone payoffs",[1] show that the additional information increases the "it won't happen to me" effect (see Yechiam & Busemeyer, 2006). This enhancement is particularly clear when the rare outcome is unattractive (as in Problem BE2). It can be explained with the assertion that in these cases the tendency to underweight rare events is reduced by the hot stove effect, which refers to the asymmetrical influence of good and bad experiences on behavior[2] (Denrell & March, 2001; Fujikawa, 2009). The additional information given by the full feedback eliminates the hot stove effect.

1.3 Exposure to other people's decisions

A natural way of receiving information about "forgone payoffs" (i.e. payoffs from alternatives that were not chosen) in everyday life is by being exposed to other people's decisions. Yechiam et al. (Yechiam, Druyan, & Ert, 2008) compared decisions from experience with and without such social exposure. Specifically they examined behavior in a typical clicking paradigm in one condition, and in another condition ("social exposure") subjects played the same task, but each subject could also see the actions and outcomes of another subject in real time. It

[1] "Full feedback" includes the realization of the obtain payoff, but also the information about the "forgone" payoff from the key that was not selected in that trial.
[2] Specifically a bad experience with the risky alternative decreases the likelihood of exploring that alternative again, and thus preventing future good experiences with that alternative that could correct the bad impression.

was found that, similarly to the effect of forgone payoffs, being exposed to another person’s decisions accelerates the “it won’t happen to me” effect.

1.4 Clicking among multiple alternatives with full feedback

Although decision dilemmas often include more than two options to choose from, most studies have focused on binary choice for simplicity reasons. To examine the relation between the number of alternatives and risky choices, Ert and Erev (2007) extended the clicking paradigm with full feedback, by creating replicas of options S and R. These replicas resulted with three different choice sets with 2, 6, and 50 alternatives to choose from. In one of the studies they examined a variant of problem 1, and found that the proportions of choice in R were 23%, 39%, and 41% under the choice sets of 2, 6, and 50 alternatives respectively. This example shows that when the number of options in the choice set increases the “won’t happen to me” effect might be somewhat reduced, though not eliminated.

1.5 The description-experience gap, and the joint effect of description and outcome feedback

The results reviewed above demonstrate the description-experience gap aforementioned in the introduction: People exhibit oversensitivity to rare events when they decide based on the description of the incentive structure, and the opposite bias when they rely on past experience. In order to clarify the relative importance of the two biases, several studies used a variant of the clicking paradigm in which the subject sees the description of the payoff structure, and in addition receives an immediate feedback after each choice (Erev at al., 2016; Jessup, Bishara, & Busemeyer, 2008; Lejarraga & Gonzalez, 2011; Yechiam, Barron, & Erev, 2005). The results reveal an overweighting of the rare event in the very first trial, and a quick elimination or even reversal of this bias (i.e., underweighting of the rare event) with experience. Similarly, a description that is given after the subject has accumulated experience does not affect the “it won’t happen to me” effect (Barron, Leider & Stack ,2008). Together the results suggest that experience have larger impact on behavior than description, and imply that warnings alone might not be sufficient to eliminate the “won’t happen to me” regularity.

1.6 The co-existence of overestimation and underweighting of rare events

Barron and Yechiam (2009) studied a variant of problem BE2 (in which the loss from R was 20 with probability of 0.15), using the clicking paradigm with full feedback and one addition: Starting at trial 201, the subjects were asked to estimate the probability of the rare outcome before they make their choice. The results revealed that the subjects overestimated the rare events, consistently with the examples presented in Table 1, but their choice reflected the opposite bias: they behaved consistently with the “it won’t happen to me” effect.

1.7 Subjective evaluation of experience: The co-existence of the peak and freq. effects

The "won't happen to me" effect appears to be inconsistent with studies that examine subjective evaluation of past experiences. This line of research reveals a "peak effect": It shows that when evaluating (retrospectively and prospectively) unpleasant experiences people tend to focus on relatively few extreme and rare key moments of the experience– the peaks (Fredrickson & Kahneman, 1993). In contrast, the "won't happen to me" pattern implies a “freq. effect”: A tendency to pay more attention to the frequent experiences. Schurr, Rodensky and Erev (2014) show that the two effects are not inconsistent; they can emerge in response to different questions. The requirement to evaluate past experience leads people to focus on the extreme and interesting cases, but the requirement to make repeated decisions leads them to exhibit the "it won't happen to me" effect.

1.8 The planning-ongoing gap

Another implication of the differences between subjective evaluation of probabilities and choice behavior relates to planning future behavior. This implication was illustrated by Yechiam, Barron, and Erev (2005). In one study they informed subjects that in each of the 100 trials of the experiment they will face the following choice problem:

Problem YBE (probability of Red is 1/200; payoffs in Agorot, 100 agorot= $0.25):

S: Loss of 8 if Red occurs, and loss of 2 otherwise

R: Loss of 100 if Red occurs, and loss of 1 otherwise

The subjects received a complete description of the payoff rule. Under condition "planning," the subjects were asked to plan their choices in advance. That is, they were asked to specify the number of trials in which they will play the risky option. Under condition "ongoing," the subjects had to specify their choice before each trial. The observed R-rate was 42% in condition "planning" (showing slight preference for the safer option S), but 69% in condition "ongoing" (showing strong preference for the riskier option R). That is, in line with one-shot decisions from description, planning decisions reflect higher sensitivity to rare events than ongoing decisions. Schurr et al. (2014) show that this effect of planning emerges even when planning is based on past experiences and the subjects cannot rely on a complete description of the incentive structure.

2 Studies of one-shot decisions from experience: The sampling paradigm

2.1 The cards sampling paradigm

Hertwig, Barron, Weber and Erev (Hertwig, Barron, Weber, & Erev, 2004), and Weber, Shafir, and Blais (2004) suggested an alternative to the clicking paradigm to study decisions from experience: the "cards sampling" paradigm. In this paradigm the alternatives are presented as two decks of cards. The decision maker samples independent draws from each deck of cards as many times as she likes. Then, when she feels she had sampled enough from the decks she can move on to a "decision stage" in which she has to choose once the deck from which she likes to draw a random card for "real money". Therefore, the most significant difference between the "clicking" and the "sampling" paradigms is that the latter separates between information acquisition (sampling stage) and choice (decision stage). This separation does not change the behavioral pattern: people still seem to behave as if "it won't happen to me". A recent study by Erev et al. (2010) compared the sampling and the clicking paradigms in 120 choice problems, and found that the level of risk taking in the two paradigms is highly correlated ($r = 0.83$, $p < .0001$). However, this separation seems useful in studying the relation between information sampling processes and the decisions.

2.2 Representative samples

A typical observation in studies of the sampling paradigm is that people tend to be satisfied with small samples, typically 7-15 samples from each alternative (Hertwig et al., 2004; Hertwig & Erev, 2009). This tendency results with underrepresentation of rare events in the sampled payoff distribution and facilitates the "won't happen to me" effect. Different approaches have been taken to explore the role of unrepresentative samples. Hau et al. (2008) forced subjects to draw 100 samples before they make their decisions to ensure they encounter the rare event. Ungemach et al. (2009; see also Camilleri & Newell, 2009; Hadar & Fox, 2009) fixed the sample so all payoffs are encountered during the sampling phase. The results show that while the effect of "it won't happen to me" is attenuated, it is still apparent even under representative samples.

2.3 Sampling multiple alternatives

Hills, Noguchi, and Gibbert (2013) examined the role of the choice set size in the sampling paradigm. They compared behavior in different conditions of the sampling paradigm that included 2, 4, 8, 16, and 32 alternatives. They found that when the number of alternatives increases people sample more overall but sample each prospect less. Therefore, the increased number of alternatives facilitates the "it won't happen to me" effect.

2.4 Sampling ambiguous prospects, and the promotion of new products

People tend to prefer "known risks" (whose probabilities are known) over equivalent "unknown risks" (whose probabilities are ambiguous), a phenomenon known as "ambiguity aversion" (Camerer & Weber, 1992; Ellsberg, 1961). Ert and Trautmann (2014) studied the effect of experience on ambiguity aversion by letting their subjects sample the "unknown risk". They found that this sampling experience eliminates the ambiguity aversion tendency, and leads people to exhibit the "it won't happen to me" effect. In a related study on product promotion, Ert, Raz, and Heiman (in press) studied consumer responses to products that are beneficial overall (i.e., whose expected values exceed their costs), but for which the distribution of values is highly skewed (e.g., longshot lotteries or safety-related products), so that they yield large benefits with low probability. In that context, they found that letting consumers experience these products before making a purchase decision was counterproductive, because consumers were too sensitive to the "typical" performance while experiencing the product (in which large benefits were most often not received). Therefore, such personal experience with a product actually lowered consumers' tendency to buy the sampled product despite its advantages.

3 "It won't happen to me" effect in other paradigms of decisions from experience

Most studies of decisions from experience have used variants of either the clicking paradigm, or the card sampling paradigm, reviewed above. However, some studies have used other paradigms and also found evidence for people exhibiting the "it won't happen to me" phenomenon. In this section we review some of these studies.

3.1 Probability matching

Most early studies of decisions from experience use the probability learning paradigm. In each trial of these studies (Estes & Suppes, 1959; Grant, Hake, & Hornseth, 1951; and see review by Vulkan, 2000) subjects have to guess which of two light bulbs will be turned on. Subjects do not receive prior information concerning the underlying probability, which is fixed throughout the experiment. To maximize performance the subjects should always select the bulb that was turned on more often in the past. The results reveal that the subjects deviate from this strategy in the direction of "probability matching". For example, Grant et al. (1951) studied a condition in which the optimal strategy led to accurate guess in 75% of the trials, and the results reveal that the choice rate of the optimal response was 75%.[3]

At first glance, the probability matching pattern appears to be inconsistent with the "won't happen to me" effect; this deviation from maximization might indicate oversensitivity to the rare event. However, Erev and Barron (2005) show that the probability matching bias and the "won't happen to me" effect can be products of the same cognitive tendency: The tendency to rely on small samples of past experiences.

[3] Follow-up research (see Bereby-Meyer & Erev, 1998; Edwards, 1961; Siegel, 1961) show that the magnitude of the deviation from optimal choice is diminished with time in longer experiments. Yet, the bias in the direction of probability matching does not disappear.

3.2 Time saving decisions

Most studies of decisions from experience have focused on choice between monetary outcomes. Yet everyday choices are sometimes associated with nonmonetary outcomes, a typical example is the motivation of minimizing time delays (e.g., on daily commuting to work). Munichor, Erev and Lotem (2006) replaced monetary outcomes with time delays (in seconds) in the clicking paradigm to find that people's timesaving decisions is similar to their money-related decisions from experience: A risky prospect is more attractive than a safer prospect with the same expected value only when it leads to a better outcome most of the time.

3.3 Signal detection tasks

Barkan, Zohar and Erev (1998) examined choices in a signal detection task. In each trial subjects were presented with a square placed on certain height on a screen, and had to classify that square (the signal) as "High" or "Low" on their screen. In one condition, the decision "Low" maintained the status quo, and the decision "High" could lead to a gain of 1 point if "High" was the right classification, or a loss of 10 points if it was the wrong one. The exact probability of a gain increased with the height of the square, and the optimal strategy implies a cutoff rule, i.e., decide "High" only when the square/signal exceeds a certain height on the screen. The results reveal that most subjects deviated from the optimal cutoff in the direction of the "won't happen to me" effect. For example, they mostly selected "High" (i.e., their cutoff was lower than optimal), even when the probability of the large loss was 10%-20%. Notice that in these cases the signal's true classification is only rarely "Low", so selecting "High" leads to a better outcome most of the time. However, such decisions also imply a negative expected return since the expected loss is higher than 1 while the expected gain is less than 0.9 in these cases.

3.4 Other animals

Shafir et al. (2008) compared repeated choices of humans and honeybees (Apismellifera) between a "safe" option that provided a gain with certainty, and a risky option that provided a higher gain but was associated with a rare relative loss. The results showed that when those options could be easily discriminated both humans and honeybees did not pay enough attention to the possibility of the rare relative loss. Both species behaved as if "it won't happen" to them.

4 Interpretation and boundary conditions

Kahneman and Tversky’s (1979) hypothesized that “because people are limited in their ability to comprehend and evaluate extreme probabilities, highly unlikely events are either neglected or over-weighted, and the difference between high probability and certainty is either neglected or exaggerated.” (p. 283). Under one interpretation of the results summarized in the previous sections they clarify the conditions under which rare events are neglected: Neglect is more likely in decisions from experience than in decisions from description. Under a weaker interpretation of the results, the “it won’t happen” effect does not reflect a complete neglect of the rare events. Rather, it implies that experience reduces the subjective weighting of the rare events. The experiments described below compare the two interpretations.

4.1 Rare events: neglected or underweighted

The main difference between the "neglect" and the "underweighting" explanation of the "it won’t happen" effect involves the assumed effect of the expected payoffs. If rare events are neglected, their effect on the expected payoff is irrelevant. In contrast, underweighting implies sensitivity to the effect of the rare event on the expected payoffs; extreme rare events can drive choice behavior even if they are underweighted. We investigate this by testing whether subjects are more attentive to rare events when their consequences are sufficiently severe (as in the “Distinct EV” choice problem presented in Figure 3), than when they are less severe (as in the “Similar EV” problem presented in Figure 3).

Problem	Option S	Option R
Similar EV	2.52	(2.53, 0.89; 2.43) [EV = 2.519]
Distinct EV	2.52	(2.53, 0.89; 2.03) [EV = 2.475]

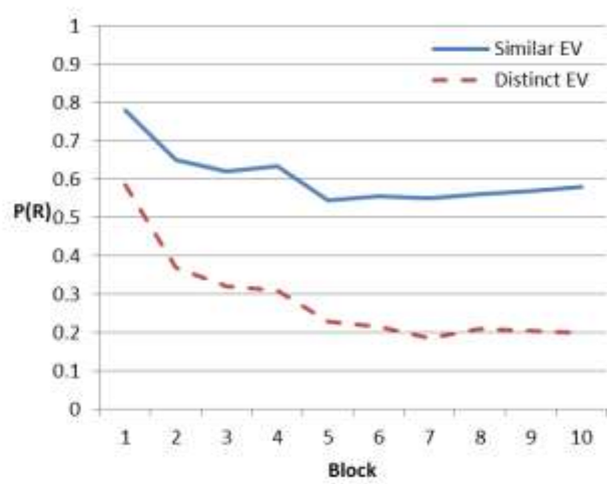

Figure 3. Proportion of choices in Option R (P(R)) in 10 blocks of 40 trials in problems Similar EV (SEV) and Distinct EV (DEV). The notation (x, p; y) refers to a prospect that yields outcome x with probability p and outcome y otherwise (with probability 1-p).

Both problems involve a choice between a certain payoff (2.52), and a risky prospect that usually pays a higher payoff (2.53), but pays a lower payoff with low probability. The problems differ with respect to the outcome of the low probability event. In Problem Similar EV the outcome of the low probability event is moderate (its distance from the common outcome is only 10 time the difference between the common outcome and that of choosing S), and in Problem Distinct EV the rare outcome is significantly lower, implying a noticeable difference between the EVs of the two options. The assertion that people neglect/ignore rare events implies a high preference for R in both problems, since option R is better in 89% of the time, and EVs would be similar if the rare outcome is ignored. If, however, the outcome of the rare event is not neglected but underweighted, then even though option R looks more attractive most of the time, people may learn to notice the significant difference in EV that is implied by this option. Thus this hypothesis implies a preference for R in Problem Similar EV, but not in Problem Distinct EV where the rare event has higher impact on the EV of option R.

In order to compare the two interpretations, we let 40 Technion students play the clicking paradigm with full feedback for 400 trials and for real money. Half of them played problem Similar EV and the other half played problem Distinct EV.

The results reveal that subjects learned to avoid the risky option when the rare event had high impact on their expected value (red line in Figure 3), but much less so when the rare event had low impact on their expected value (blue line in Figure 3). More specifically, the rate of risky choice (i.e., choice in option R) across the 400 trials was 60% in Problem Similar EV, but only 28% in problem Distinct EV. Figure 3 shows that the first block of trials reveals high R rates, which did not significantly differ between problems: 80% in problem Similar EV and 69% in problem Distinct EV. With time the mean R rates mildly reduced in problem Similar EV, by 21% from the first to the last block, and significantly reduced by 48% in problem Distinct EV[4].

[4] The difference in r-rate between problem similar EV and distinct EV is significant, $t(38) = 3.02$, $p = .004$; the reduction between the first and last blocks in problem Distinct EV is significant, $t(19) = 5.5$, $p < .0001$;

Together the results support the hypothesis that rare events are underweighted, not neglected: subjects choices reflected insufficient attention to rare events, but when rare events were sufficiently important subjects learned to take them into account.

4.2 *Is underweighting affected by absolute or relative EV differences?*

The finding that rare events are underweighted, rather than neglected, raises a natural question: exactly what conditions would make the outcome of the rare event "sufficiently significant" to impact behavior? One account for the current findings is that people attend to the *absolute* EV difference between the proposed options. Another account suggests that people respond to the differences in expected value *relative* to the payoff variance (Weber et al., 2004).

We conducted an additional study to differentiate the "sensitivity to absolute EV" from the "sensitivity to relative EV" hypotheses. The study compares the problems presented in Figure 4. In all problem option R is associated with lower EV than option S. Yet in problem ADEV (Absolute Difference in EV) the difference between the expected values is 11 times higher than in Problem Base. Therefore, in accordance with the results reported in section 4.1, we predict that option R will be more attractive in problem Base than in problem ADEV. Problem RDEV (Relative Difference in Expected Value) is added to examine the role of the relative EV differences. The new Problem RDEV was designed so that it is similar to Problem Base with regard to the absolute EV difference between the safe and risky options, but similar to problem ADEV with regard to the relative EV difference. Thus if the absolute EV difference drives the effect of rare events then the R-Rate in Problem ADEV is expected to be lower than the R-rate in the two other problems. Alternatively if relative difference in EV matters then the R-rates in both problems ADEV and RDEV are expected to be similar, but lower from the R-rate in problem Base.

Forty-eight Technion students participated in this study. The procedure was identical to that of the study reported in section 4.1 with the exception that each subject played all problems, which were presented in a random order. Each problem was played for 100 trials.[5]

[5] Problem Base is reported by Nevo and Erev (2012), and the other two problems were added for this study. Subjects were also presented with a forth "filler" problem (a choice between a sure 0 and a gamble that yields 1 with probability of 0.1 and -10 otherwise) that was run for the purposes of another study.

Prob.	Option S	Option R	EV diff.	Relative EV diff.[6]
Base	0	(1, 0.9; -10)	-0.10	-.030
ADEV	0	(1, 0.9; -20)	-1.10	-.175
RDEV	0	(0.1, 0.9; -2)	-0.11	-.175

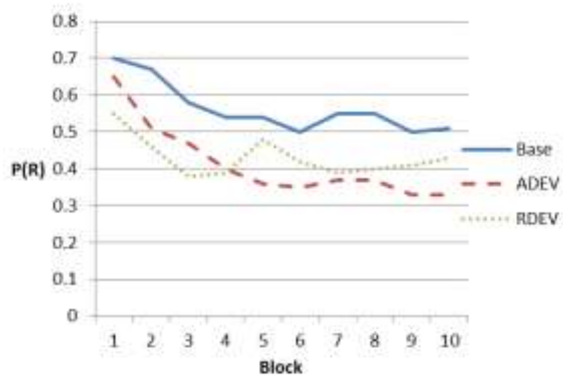

Figure 4. Proportion of choice in option R in 10 blocks of 40 trials in problems Base, ADEV (Absolute difference in EV), and RDEV (Relative difference in EV). Each problem involves a choice between option S that yields 0 with certainty, and Option R that yields x with probability of 0.9, -y otherwise, when x equals 1,1,and 0.1 and y equals -0.10, -1.10, and -0.11 in problems Base, ADEV, and RDEV respectively. Payoffs were in Sheqels, 1 Sheqel = $.25. The notation (x, p; y) refers to a prospect that yields outcome x with probability p and outcome y otherwise (with probability 1-p).

The results reveal that the R-rate (i.e., proportion of risky choice) in problem ADEV (41%) is significantly lower than in problem Base (56%). This result replicates the findings from the study in section 4.1. The Overall R-rate in Problem RDEV (43%) is also significantly lower than in problem Base[7]. However, no significant difference in R-rate was found between problems ADEV and RDEV.[8] Thus it seems that the difference in EV *relative* to the payoff variance (rather than the absolute EV difference) is the factor that accounts for the observed behavioral differences across problems.

4.3 *Two variants of a basic sampler model*

Previous research has shown that the basic properties of decisions from experience can be captured with simple models that assume noisy reliance on past experiences (Erev, Ert, & Yechiam, 2008). The basic model assumes random choice in the first trial, and that each of the

---

[6] A technical problem with the relative EV measure for payoffs that are certain is that the dominator is zero, to avoid dividing by zero we added an epsilon of .0001 to the denominator.

[7] The difference between r-rates in problems ADEV and Base is significant, $t(47) = -4.03$, $p<.001$; r-rate in problem RDEV also significantly differ from problem Base, $t(47) = 2.76$, $p = .008$.

[8] Figure 4 presents the R-rate in each of the problems over 10 blocks of 10 trials. The figure reveals that the R-rates were high in all conditions in the first block of trials (70%, 65%, and 55% in problems Base, ADEV, and RDEV respectively). It also shows significant reductions in risk taking from the first to the last block in all conditions: 19%, $t(47) = 3.75$, $p = .0005$. in problem Base; 32%, $t(47) = 6.01$, $p < .0001$ in problem ADEV; and 11% $t(47) = 1.91$, $p = .063$ in problem RDEV.

following decisions is based on a small sample of κ_i (property of agent *i*) randomly drawn past experiences. The agent selects the risk option if and only if:

(1) SMR-SMS > 0

where SMR, and SMS are the mean payoffs in the sample of κ draws from R and S respectively. The sample size κ_i is a free parameter that reflects a property of the different agents and is drawn from the set $\{1, 2, \ldots \kappa\}$. The model best captures the data of the two studies summarized in sections 4.1 and 4.2 with an estimated parameter of $\kappa_i = 23$, the Mean Square Deviation (MSD) is 0.003.

The "sensitive sampler" model is a variant of the basic model that assumes sensitivity to the grand mean. It is identical to the basic model with the exception that equation 1 is replaced with:

(2) (GMR-GMS) + (SMR-SMS) > 0

where the added terms GMR, and GMS are "grand means", i.e., the mean payoffs from R and S respectively in all previous trials. The sensitive sampler model best fit the data with an estimated parameter of $\kappa_i = 17$, and has a Mean Square Deviation (MSD) of 0.0009.

Comparison of the two models shows that the added assumption of the agent's sensitivity to the alternative's grand mean improves the model's descriptive value without any addition of parameters. The better fit results mostly from the model's higher sensitivity to the differences between the problems EV, such as the difference between problem Similar EV and Distinct EV. Notice that the basic sampler model already captures some of this sensitivity by assuming that the agent's sample size is relatively large. Accordingly the sample size is estimated to be much lower in the sensitive sample model ($\kappa_i = 17$) than in the basic sampler model ($\kappa_i = 23$).

5 The impact of extreme risks and potential implications

The experimental studies summarized above focus on abstract situations, associated with relatively small objective risk. The choice task involved clicking, and the maximum loss from risky behavior was less than $3. The focus on abstract situation in the lab allows the study of a fully controlled environment that is crucial to differentiate hypotheses (as demonstrated in section 4 above). In the current section we overview several field studies that evaluate the potential implications of the "it won't happen to me" phenomenon in the "real world".

5.1 Car Radio with detachable panels

The difference between planning and ongoing decisions suggests that sometimes people buy safety devices, but "learn" with time to neglect them. One example of this buying-(not)using gap is a study, by Yechiam et al. (2006), that focuses on car radios with a detachable panel that were popular in Israel when this study was conducted. The detachable radio panel provides protection against theft but only when it is used (i.e., when the panel is detached).

The decision to buy a detachable panel relies on its value as a safety device. The decision not to detach the panel is made without an explicit presentation of a threat, and is mostly shaped by experience. Thus, the "it won't happen" effect implies a decrease in the tendency to use the panel with experience, as the small probability of theft is underweighted. Yechiam et al. surveyed Israelis on this issue, and found that the large majority (96%) of Israelis who bought car radios between 1995 and 2003 preferred the type with a detachable panel although it was more expensive. Most respondents detached the panel in the first two weeks, but were much less likely to detach it after a year. That is, responders seemed to underweight the probability of theft when they made their decisions from experience, despite their initial concern of theft that led them to buy such expensive detachable panels in the first place.

5.2 The effect of rare terrorist attacks

The impact of terrorism on tourism represents one of the main economic effects of terrorism (Weimann, 1993). The "it won't happen" effect may have several implications: first, it suggests that the frequency of attacks might be more effective than their magnitude. A study conducted on the impact of terrorism on tourism demand in Israel during 1991 to 2001 (Pizam &

Fleischer, 2002) found just that: the frequency of acts of terrorism had caused a larger decline in international tourist arrivals than the severity of these acts. The second implication is that local residents would be less impacted than international tourists as the former have gathered safe experience, and underweight the rare event of a terrorist act (Yechiam et al., 2005).

5.3 The enforcement of safety rules

The research reviewed above has three implications for the design of safe working environments (see Erev & Rodensky, 2004 ; Schurr, Erev & Rodensky, 2014; and related ideas in Zohar, 1980). First, the results suggest that rule enforcement is necessary even when safe behaviors, e.g., the use of safety equipment, are the optimal way of action. An explanation of the relevant risks might not be enough, as when workers make decisions from experience they are likely to underweight the low-probability-high-hazard event and behave as if they believe that it won’t happen to them.

A second implication concerns the effectiveness of rule enforcement systems in which a small proportion of the violations are severely punished (Becker, 1968). Systems of this type are likely to be effective in the context of decisions from description, but less effective in contexts of decisions from experience since low probability punishments are likely to be underweighted. The third implication suggest that the fact that workers take unnecessary risks and seem to ignore safety rules does not imply that they would object attempts to enforce these rules. Indeed, the planning –ongoing gap implies that when workers would be explicitly asked to consider the safety issue they would agree that they want to behave safely, and would be happy to see that the management designs a rule enforcement system to help them achieve this goal.

Finally, the arguments presented above suggest that behavior is much more sensitive to the probability than to the magnitude of the punishment. Thus, a gentle Continuous Punishment ("gentle COP") policy that implies low punishments with high probability can be very effective as long as the fine is larger than the benefit from violations of the rule and the risk of avoidance behavior is low.

Erev and Rodensky (2004, and see Erev, 2007; Schurr et al., 2014) applied this “gentle COP” method in twelve Israeli factories. They designed a mechanism by which supervisors approached each worker who violated a safety rule and reminded him that this behavior might result in injury, and would be recorded if repeated. The official role of these "violations records" was to allow the management to positively reinforce workers who followed the safety rule by giving these workers a higher probability of winning a lottery. Baseline data were collected about two months prior to intervention, which included objective measures of the workers' safety behaviors. Figure 7 presents measures of adherence to safety rules before and during the intervention in one department of one of these factories. The data was collected by the research team, and was independent of the supervisors' comments and records.

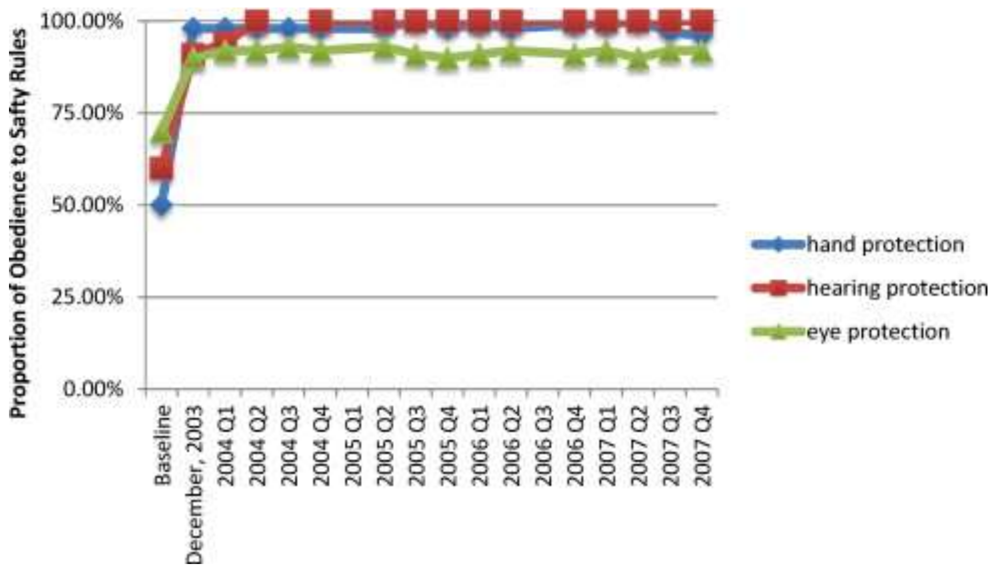

Figure 7. (copied with permission from Schurr et al., 2014). Proportion of workers who followed 3 safety rules before and during the "gentle COP" intervention

As the example in Figure 7 shows, the intervention had a large and immediate positive effect. A similar pattern was observed in all twelve factories. The rate of safe behaviors increased to 90% immediately after the beginning of the intervention and has not diminished within the next two years of measurement. Given the success of the intervention, and its relatively low cost, the factories have decided to maintain the experimental policy.

5.4 *The limitations of warnings*

Warnings are considered to be an important information source that is designed to protect people by encouraging them to avoid risks. People's tendency to overweight the probability of rare disasters when they respond to described information suggests that warnings can be indeed very effective in facilitating safety. Nevertheless, the “it won’t happen to me” effect suggests important limitations to the effectiveness of warnings. One limitation suggests that when people are warned against engaging in risky behavior only after having past experience, the warning is ineffective in eliminating the “it won’t happen to me” effect (see Barron et al., 2008). Another limitation refers to cases where the accuracy of warning information uncertain (e.g., weather warnings). In such cases a tradeoff exists between the probability of detection and false alarms. Intuition suggests that the costs of false alarms of rare disasters (e.g., tornados) should be much lower than the costs of failing to warn from them. Yet experiencing false alarms might lead people to learn erroneously that the warning is ineffective and discourage them from taking the necessary safety measures. In line with this concern a recent examination of the relation between false alarm ratios and tornado casualties across the US from 1984-2004 revealed that one standard deviation in the false alarm ratio increased expected fatalities by between 12% and 29% (Simmons & Sutter, 2009).

5.5 Moral Hazards

Insurers and economists are often worried about the possibility that having insurance might change behavior of insured persons in ways that will increase insurance claims. Moral hazard is defined as the “intangible loss-producing propensities of the individual assured” (Pauly, 1968). Economists have differentiated between “ex-ante” moral hazard, which refers to taking more risks (e.g., reduction in preventive effort) once the individual is insured, and “ex-post” moral hazard, which refers to increasing demand for medical care. Zweifel and Manning (2000) review the evidence for both types of moral hazard and find, that at least in health-care, the evidence for ex-ante moral hazard is weak, while the evidence for ex-post moral hazard is much stronger. The “it won’t happen to me” phenomenon can explain this interesting difference. It suggest that people take risks because they believe that “it won’t happen to me” and underweight the probability of rare event, and they are much less affected by its magnitude. Thus, reducing the outcome magnitude of the rare event is not likely to change risky behavior.

6. Summary

The current analysis suggests that there are many situations in which the typical decision maker behaves "as if" he or she believes that "it won't happen to me." The tendency to underweight rare events is particularly robust when people make ongoing decisions based on past experience, and the difference between the expected values of the different options is relatively small. These results can be captured with the assumption that decisions from experience reflect a tendency to rely on a small sample of past experiences. In addition, the results show high sensitivity to rare events in one-shot decisions from experience, in planning decisions, and in probability estimation. Review of field and intervention studies suggests that the understanding of the conditions that trigger under- and over-weighting of rare events can be used to design policies that facilitate wise reaction to extreme risks.

References

Barkan, R., Zohar, D., & Erev, I. (1998). Accidents and decision making under uncertainty: A comparison of four models. *Organizational Behavior and Human Decision Processes*, *74*(2), 118–144.

Barron, G., & Yechiam, E. (2009). The coexistence of overestimation and underweighting of rare events and the contingent recency effect. *Judgment and Decision Making*, *4*(6), 447–460.

Becker, C. (1968). Punishment: An Economic Approach, 76J. *Pol. Econ*, *169*(10.2307), 1830482169.

Bereby-Meyer, Y., & Erev, I. (1998). On learning to become a successful loser: a comparison of alternative abstractions of learning processes in the loss domain. *Journal of Mathematical Psychology*, *42*(2), 266–286.

Camerer, C., & Weber, M. (1992). Recent developments in modeling preferences: Uncertainty and ambiguity. *Journal of Risk and Uncertainty*, *5*(4), 325–370. http://doi.org/10.1007/BF00122575

Camilleri, A. R., & Newell, B. R. (2009). The role of representation in experience-based choice. *Judgment and Decision Making*, *4*(7), 518–529.

Denrell, J., & March, J. G. (2001). Adaptation as information restriction: The hot stove effect. *Organization Science*, 523–538.

Edwards, W. (1961). Probability learning in 1000 trials. *Journal of Experimental Psychology*, *62*(4), 385.

Ellsberg, D. (1961). Risk, Ambiguity, and the Savage Axioms. *The Quarterly Journal of Economics*, *75*(4), 643–669.

Erev, I., & Barron, G. (2005). On adaptation, maximization, and reinforcement learning among cognitive strategies. *Psychological Review*, *112*(4), 912.

Erev, I., Ert, E., Plonsky, O., Cohen, D., & Cohen, O. (2016). From Anomalies to Forecasts: A Choice Prediction Competition for Decisions under Risk and Ambiguity. Retrieved from http://departments.agri.huji.ac.il/economics/teachers/ert_eyal/CPC2015.pdf

Erev, I., Ert, E., & Yechiam, E. (2008). Loss aversion, diminishing sensitivity, and the effect of experience on repeated decisions. *Journal of Behavioral Decision Making*, *21*(5), 575–597. http://doi.org/10.1002/bdm.602

Ert, E., & Erev, I. (2007). Replicated alternatives and the role of confusion, chasing, and regret in decisions from experience. *Journal of Behavioral Decision Making*, *20*(3), 305–322. http://doi.org/10.1002/bdm.556

Ert, E., Raz, O., & Heiman, A. (2016). (Poor) seeing is believing: When direct experience impair product promotion. *International Journal of Research in Marketing*.

Ert, E., & Trautmann, S. T. (2014). Sampling experience reverses preferences for ambiguity. *Journal of Risk and Uncertainty*, *49*(1), 31–42. http://doi.org/10.1007/s11166-014-9197-9

Estes, W. K., & Suppes, P. (1959). *Foundations of statistical learning theory. II. The stimulus sampling model*. Stanford University, Applied Mathematics and Statistics Laboratory, Behavioral Sciences Division. Retrieved from http://suppes-corpus.stanford.edu/techreports/IMSSS_26.pdf

Fox, C. R., & Tversky, A. (1998). A Belief-Based Account of Decision Under Uncertainty. *Management Science*, *44*(7), 879–895. http://doi.org/10.1287/mnsc.44.7.879

Fredrickson, B. L., & Kahneman, D. (1993). Duration neglect in retrospective evaluations of affective episodes. *Journal of Personality and Social Psychology*, *65*(1), 45.

Fujikawa, T. (2009). On the relative importance of the hot stove effect and the tendency to rely on small samples. *Judgment and Decision Making*, *4*(5), 429–435.

Grant, D. A., Hake, H. W., & Hornseth, J. P. (1951). Acquisition and extinction of a verbal conditioned response with differing percentages of reinforcement. *Journal of Experimental Psychology*, *42*(1), 1.

Hadar, L., & Fox, C. R. (2009). Information asymmetry in decision from description versus decision from experience. *Judgment and Decision Making*, *4*(4), 317–325.

Hau, R., Pleskac, T. J., Kiefer, J., & Hertwig, R. (2008). The description-experience gap in risky choice: the role of sample size and experienced probabilities. *Journal of Behavioral Decision Making*, *21*(5), 493–518. http://doi.org/10.1002/bdm.598

Hertwig, R., Barron, G., Weber, E. U., & Erev, I. (2004). Decisions from Experience and the Effect of Rare Events in Risky Choice. *Psychological Science*, *15*(8), 534 –539. http://doi.org/10.1111/j.0956-7976.2004.00715.x

Hertwig, R., & Erev, I. (2009). The description-experience gap in risky choice. *Trends in Cognitive Sciences*, *13*(12), 517–523. http://doi.org/16/j.tics.2009.09.004

Hills, T. T., Noguchi, T., & Gibbert, M. (2013). Information overload or search-amplified risk? Set size and order effects on decisions from experience. *Psychonomic Bulletin & Review*, *20*(5), 1023–1031.

Jessup, R. K., Bishara, A. J., & Busemeyer, J. R. (2008). Feedback Produces Divergence From Prospect Theory in Descriptive Choice. *Psychological Science*, *19*(10), 1015 –1022. http://doi.org/10.1111/j.1467-9280.2008.02193.x

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263–291.

Lejarraga, T., & Gonzalez, C. (2011). Effects of feedback and complexity on repeated decisions from description.

Marchiori, D., Di Guida, S., & Erev, I. (2015). Noisy retrieval models of over-and undersensitivity to rare events. *Decision*, *2*(2), 82.

Munichor, N., Erev, I., & Lotem, A. (2006). Risk attitude in small timesaving decisions. *Journal of Experimental Psychology: Applied*, *12*(3), 129.

Nevo, I., & Erev, I. (2012). On surprise, change, and the effect of recent outcomes. *Frontiers in Psychology*, *3*. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3283116/

Pauly, M. V. (1968). The Economics of Moral Hazard: Comment. *The American Economic Review*, *58*(3), 531–537.

Phillips, L. D., & Edwards, W. (1966). Conservatism in a simple probability inference task. *Journal of Experimental Psychology*, *72*(3), 346.

Pizam, A., & Fleischer, A. (2002). Severity versus frequency of acts of terrorism: Which has a larger impact on tourism demand? *Journal of Travel Research*, *40*(3), 337–339.

Schurr, A., Rodensky, D., & Erev, I. (2014). The effect of unpleasant experiences on evaluation and behavior. *Journal of Economic Behavior & Organization*, *106*, 1–9.

Shafir, S., Reich, T., Tsur, E., Erev, I., & Lotem, A. (2008). Perceptual accuracy and conflicting effects of certainty on risk-taking behaviour. *Nature*, *453*(7197), 917–920.

Siegel, S. (1961). decision making and learning under verying conditions of reinforcement. *Annals of the New York Academy of Sciences*, *89*(5), 766–783.

Simmons, K. M., & Sutter, D. (2009). False alarms, tornado warnings, and tornado casualties. *Weather, Climate, and Society*, *1*(1), 38–53.

Ungemach, C., Chater, N., & Stewart, N. (2009). Are Probabilities Overweighted or Underweighted When Rare Outcomes Are Experienced (Rarely)? *Psychological Science*, *20*(4), 473 –479. http://doi.org/10.1111/j.1467-9280.2009.02319.x

Vulkan, N. (2000). An economist’s perspective on probability matching. *Journal of Economic Surveys*, *14*(1), 101–118.

Weber, E. U., Shafir, S., & Blais, A. R. (2004). Predicting risk sensitivity in humans and lower animals: risk as variance or coefficient of variation. *Psychological Review*, *111*(2), 430.

Weimann, G. (1993). *The Theater of Terror: Mass Media and International Terrorism*. New York: Longman Group United Kingdom.

Yechiam, E., Barron, G., & Erev, I. (2005). The Role of Personal Experience in Contributing to Different Patterns of Response to Rare Terrorist Attacks. *Journal of Conflict Resolution*, *49*(3), 430–439. http://doi.org/10.1177/0022002704270847

Yechiam, E., & Busemeyer, J. R. (2006). The effect of foregone payoffs on underweighting small probability events. *Journal of Behavioral Decision Making*, *19*(1), 1–16.

Yechiam, E., Druyan, M., & Ert, E. (2008). Observing others’ behavior and risk taking in decisions from experience. *Judgment and Decision Making*, *3*(7), 493–500.

Yechiam, E., Erev, I., & Barron, G. (2006). The effect of experience on using a safety device. *Safety Science*, *44*(6), 515–522.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of Applied Psychology*, *65*(1), 96.

Zweifel, P., & Manning, W. G. (2000). Chapter 8 Moral hazard and consumer incentives in health care. In Anthony J. Culyer and Joseph P. Newhouse (Ed.), *Handbook of Health*

Economics (Vol. Volume 1, Part A, pp. 409–459). Elsevier. Retrieved from http://www.sciencedirect.com/science/article/pii/S1574006400801675

Table 1: *Summary of experimental studies that demonstrate overestimation of small probabilities and overweighting of rare events (following Marchiori, Di Guida, & Erev, 2015)*

Typical experimental task	Typical results and interpretation
Judgment (Phillips & Edwards, 1966) Urn A includes 30 Red Balls and 70 White balls. Urn B includes 70 Red Balls and 30 White balls. One of the two urns was randomly selected (the prior probability that A will be selected is 0.5). The experimenter sampled with replacement 4 balls from that urn. All 4 balls are Red. What is the probability that the selected urn is A?	**Overestimation** Mean estimate: 0.23 Bayes’ posterior probability: 0.01 The mean estimate of 0.23 reflects overestimation of the objective small probability (0.01).
Choice (Kahneman & Tversky, 1979) Choose between the following two options: Option S: -5 with certainty Option R: -5000 with probability of 0.001; 0 otherwise	**Overweighting** Choice rate of option R: 20%. This choice rate suggests that most subjects behave as if the probability of the rare event (-5000) is over-weighted.

Instructions	Pre choice	Post choice
The current experiment includes many trials. Your task, in each trial, is to click on one of the two keys presented on the screen. Each click will be followed by the presentation of your payoff from that click. Your final payoff will be determined by the payoff in one randomly selected trial.	Please select one of the two keys	Your payoff in this trial is 3. 3

Figure 1: The instructions, and the screens in a study that uses the basic clicking paradigm with limited feedback (Barron & Erev, 2003). In the example the subject chose Left and won 3. The exact payoffs were determined by the problem's payoff rule. For example, in Problem 1, each Left choice leads to a payoff of 3, and each Right choice leads to a payoff of 32 in 10% of the trials, and to a payoff 0 in the other 90% of the trials. The assignment of prospects to buttons and the order of the problems are randomly determined for each subject.

Problem	Option S	Option R
BE1	3	(32, 0.1; 0)
BE2	-3	(-32, 0.1; 0)

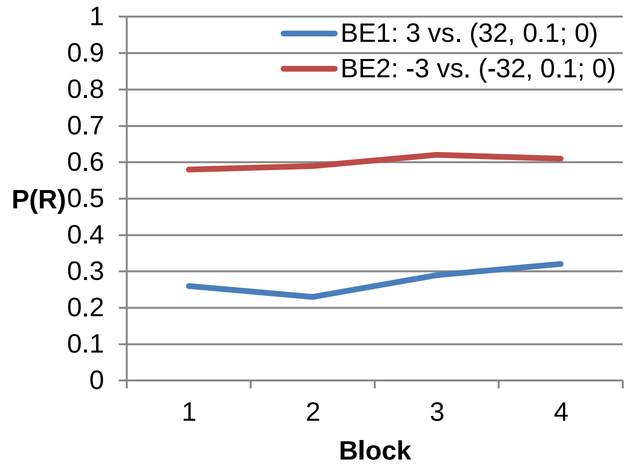

Figure 2. Problems BE1 and BE2 studied by Barron and Erev (2003). Problem BE1 involves a choice between 3 with certainty (Option S), and a gamble (32, 0.1; 0) that yields 32 with probability of 0.1 and 0 otherwise (i.e., with probability of 0.9; option R). Problem BE2 involves choice between loss of -3 (option S) and loss of -32 with probability 0.1. The options were not described but could be learned during 400 trials of repeated choice with feedback. The Figure shows the propotion of choices in the riskier Option R (P(R)) in 4 blocks of 100 trials each.

Problem	Option S	Option R
Similar EV	2.52	(2.53, 0.89; 2.43) [EV = 2.519]
Distinct EV	2.52	(2.53, 0.89; 2.03) [EV = 2.475]

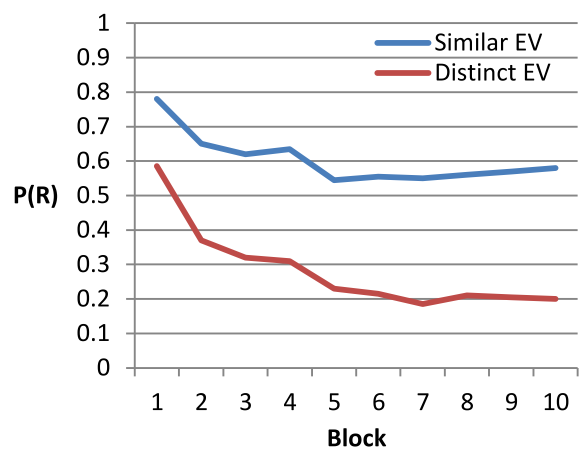

Figure 3. Proportion of choices in Option R (P(R)) in 10 blocks of 40 trials in problems Similar EV (SEV) and Distinct EV (DEV). The notation (x, p; y) refers to a prospect that yields outcome x with probability p and outcome y otherwise (with probability 1-p).

Prob.	Option S	Option R	EV diff.	Relative EV diff.[9]
Base	0	(1, 0.9; -10)	-0.10	-.030
ADEV	0	(1, 0.9; -20)	-1.10	-.175
RDEV	0	(0.1, 0.9; -2)	-0.11	-.175

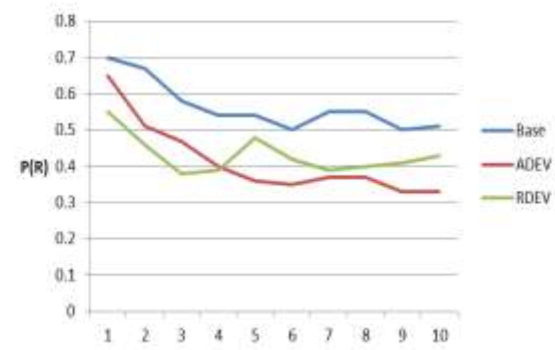

Figure 4. Proportion of choice in option R in 10 blocks of 40 trials in problems Base, ADEV (Absolute difference in EV), and RDEV (Relative difference in EV). Each problem involves a choice between option S that yields 0 with certainty, and Option R that yields x with probability of 0.9, -y otherwise, when x equals 1,1,and 0.1 and y equals -0.10, -1.10, and -0.11 in problems Base, ADEV, and RDEV respectively. Payoffs were in Sheqels, 1 Sheqel = $.25. The notation (x, p; y) refers to a prospect that yields outcome x with probability p and outcome y otherwise (with probability 1-p).

[9] A technical problem with the relative EV measure for payoffs that are certain is that the dominator is zero, to avoid dividing by zero we added an epsilon of .0001 to the denominator.

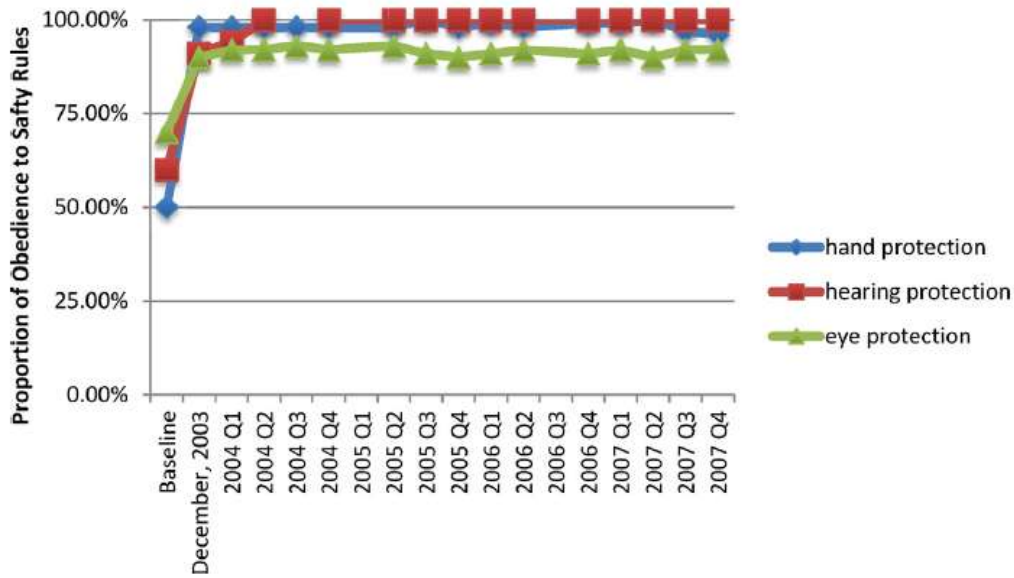

Figure 7. (copied with permission from Schurr et al., 2014). Proportion of workers who followed 3 safety rules before and during the "gentle COP" intervention