# Expected Utility versus the Changes in Knowledge Ahead

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**Abstract**

The paper is written for those seeking a decision theory appropriate for use in serious choices such as insurance. It employs stages of knowledge ahead to track satisfactions and dissatisfactions. In the first stage of the risk, the uninsured face dissatisfactions of worries and planning difficulties (avoided by the insured), also perhaps positive satisfactions of thrills (missed out by the insured). In the second stage when the risk is passed the uninsured may face the dissatisfactions of ridicule and blame if they learn that they were unlucky. From experimental and questionnaire data, people take into account such stages of knowledge ahead satisfactions and dissatisfactions. This means we must go beyond standard decision theories like expected utility or cumulative prospect theory which are irrationally atemporal single stage theories, ignoring the initial risky stage to be endured or enjoyed before learning whether one has been lucky or unlucky.

*Key words:* Primary and secondary satisfactions, Knowledge ahead, Risk, Decision-making, Decision-analysis

## 1. Introduction

The demand for insurance contracts is typically estimated via standard rank dependent theories eg EUT, axiomatised Expected Utility Theory, or CPT, Cumulative Prospect

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Theory. We focus on examining aspects of insurance demand ignored under standard theory's assumptions that

a) the choice procedure is independent of scale and context of what is at risk,
b) those demanding insurance are innately identical, and make identical choices unless facing different endowments / incentives (indeed often there is one "representative" potential buyer of the insurance contract), and
c) for both parties, choice is based on Expected Utility Theory, often simplified to expected value.

We take the opportunity to discover more realistic assumptions than a), b) and c) from laboratory generated information on how choices are made, and by integrating these findings with related investigations involving different scales and contexts, namely with the investigations of Sunstein (2003) and Schade et al. (2004).

The paper's layout is as follows. In section 2 we introduce a largely overlooked class of motivations, those based on knowledge ahead, and the issue of how potential insurees combine different motivations in reaching a decision on whether to accept a contract. In section 3 we give our experimental set-up, payment incentives and the choices that our participants made on whether or not to take out a protection contract. In sections 4 and 5 we draw conclusions, address potential objections to our lines of reasoning and indicate how our findings may be exploited.

## 2. Knowledge Ahead Based Motivations - Primary and Secondary Satisfactions

### 2.1. *EUT Contract Theory is Knowledge-Ahead-Independent*

Under Expected Utility Theory both parties value each possible net future (time discounted) sum of money that will be received, $Y_i$ $i = 1, 2, 3, \ldots$ independent of their knowledge ahead of whether $Y_i$, will occur which in turn implies that its utility $U(Y_i)$ is identical: 1, if $Y_i$, is certain (eg because an insurance contract has been signed), and 2, if $Y_i$ is risky (eg because the person decided against taking out an insurance contract), as explicated in the famous Friedman and Savage (1948) EUT analysis of "unfair" insurance contracts. The decision to accept that contract is assumed to be based on the potential insuree valuing each mutually exclusive (and thus risky) individual possible sum of money $Y_i$ $i = 1, 2, 3, \ldots$ as if each $Y_i$, were certain. Parties according to EUT exclude from consideration knowledge ahead based sources of satisfaction such as worry or excitement or inability to commit because of ignorance or merely probabilistic knowledge ahead of this size of this monetary sum. It follows that what is called "risk attitude" in EUT has nothing to do with such knowledge-ahead-based satisfactions, which are excluded. What is called "risk attitude" under EUT is instead whether:

(i) the knowledge-ahead-independent utility function is linear, so called "risk neutral",
(ii) the knowledge-ahead-independent utility function is concave, so called "risk averse"
(iii) the knowledge-ahead-independent utility function is convex, so called "risk loving"

Note that choosers do not know the outcome, and have only a limited degree of knowledge ahead whenever they have merely probabilistic knowledge of the outcomes - whenever the outcomes have non-degenerate probabilities. The characterisation of (i) to (iii) as risk attitude under EUT has nothing to do with attitude to differential degrees of knowledge

ahead, and the impact of having full (as against limited eg probabilistic), knowledge ahead. EUT usage of the term "risk attitude" thereby excludes factors like anticipating that a risky choice may involve anxiety, as Bell (1981) observed. EUT usage of the term "risk attitude" for a utility mapping that excludes attitude to degrees of risk ie attitude to degrees of knowledge ahead is confusing. The confusing usage was introduced by Marschak (1950) and became ensconced in the Arrow-Pratt measures of risk aversion. For further details, see Pope (1996/7). The reality is that the only way probabilities enter EUT is in adding up the mutually exclusive utilities, $U(Y_i)$, $i = 1, 2, 3, \ldots$. They are excluded from how the individual utilities $U(Y_i)$ are computed.

### 2.2. *Primary and Secondary Satisfactions*

To help alleviate this and other confusions on what EUT includes and excludes Pope (2001) introduces new terminology for those satisfactions included and those excluded under EUT. Call positive and negative satisfactions that stem from knowledge ahead independent sources of satisfactions primary. These are those included in EUT contract models. Call positive and negative satisfactions that stem from knowledge ahead based sources of satisfactions secondary. They are termed secondary since they derive from primary satisfactions, not because they are less important.
In related contexts, experimental and epidemiological data afford evidence of the importance of negative secondary satisfactions, eg Mellers et al. (1997, 1999, 2001), Sunstein (2003) and Schade et al. (2004). As will be shown in our experimental findings, negative secondary satisfactions frequently determine whether the contract is chosen.
Omitting secondary satisfactions generates substantial downward biasses in the demand for insurance contracts. This had been recognised by Hart (1930) quoted in Vickrey (1945). Hart had discerned like Bell that EUT is too narrow for contract theory since it excludes secondary satisfactions. Taking out insurance contracts on valuables is partly or wholly motivated by the negative secondary satisfactions of anxiety, worry and concern.

### 2.3. *Objections to Secondary Satisfactions*

There have been four objections to including consideration of secondary satisfactions in contract analyses. The first objection is that the Loomes and Sugden (1982) regret and rejoicing model, is not the best predictor of experimental evidence. This is no argument against secondary satisfactions, being important. It is rather evidence against Loomes and Sugden's: a) functional form for two secondary satisfactions, namely regret and rejoicing, b) exclusion of all the other secondary satisfactions that would normally confound identification of regret and rejoicing effects, and c) assumption that regret and rejoicing are context and scale independent. It should also be noted that the designs used for comparing EUT's relative predictive power employed an inappropriate set-up. With inappropriate cage set-ups of Skinnerian behaviourism, Darwin's hypotheses (1874) on the importance of secondary satisfactions could not be investigated, Barnett and Cowan (1976), and that sufficient time is essential in the laboratory set-up for detecting related effects, eg Hassenzahl and Borcherding (2004).
A second objection to including secondary satisfactions is that they are misperceived

as exclusively frivolous or trivial or absent from serious choices or even unethical, eg Ramsey (1926, 1950), Marschak (1950). This misperception is partly a function of the social gambling contexts many scientists used for understanding them. Once more serious contexts are used, more serious examples come to light that many traditions deem it would be unethical indeed delinquent to ignore, Pope (1983). Good decision making requires emotional inputs from factors like fear, Damasio (1984) and fear is a secondary satisfaction.

A third objection to extending contract theory to include secondary satisfactions is the claim that there is no need, that secondary satisfactions are already in EUT. There are several different phrases used for saying how secondary satisfactions are already in EUT. On is to say that they are in EUT once the outcomes (and hence acts) are properly elaborated / defined, eg Samuelson (1952a), Markowitz (1959), Caplin and Leahy (2001). Another is to say that they are in EUT once the decision situation is fully described including all its opportunity costs, eg Luce and Raiffa (1957), Stiglitz and Weiss (1981), Gale and Hellwig (1985), Kiyotaki and Moore (1997). The third is to pronounce that whichever satisfactions should be in are already included under EUT's "consistency requirements", Savage (1954) [1] , or even by "definition", eg Ellsberg (1954) quoted approvingly in Schoemaker (1982). Some of these scientists state explicitly that von Neumann and Morgenstern erred in their interpretation of EUT, eg Ellsberg, sometimes explicitly but expressing puzzlement and disappointment about this disagreement, eg Savage (1954), while many more recent ones have never heard about the heated disputes of the early 1950s on whether EUT omits anything that matters, and thus have no notion that their interpretation of EUT is the reverse of that held by von Neumann and Morgenstern.

But as Bell (1981) and Loomes and Sugden (1982) implicitly assert, and as explicitly addressed and proved in Pope (1983, 1984, 2000, 2004), von Neumann and Morgenstern had the correct interpretation, namely that EUT excludes secondary satisfactions. Including secondary satisfactions in EUT destroys its axiomatic base of EUT. Secondary satisfactions cannot be consistently included in EUT's utility mapping with EUT still identifying a unique act (or unique set of best acts) in each given choice set.

The final objection to including secondary satisfactions in contract theory is that they introduce contradictions, and thus are irrational satisfactions ones akin to "mistakes of arithmetic", eg Marschak (1950). There are three ways of tackling this objection. One is to do it from first principles and argue for the reasonableness of including consideration of at least some of them in prescriptive and normative work, eg Bell (1981), Loomes and Sugden (1982), Pope (1983, 1984). The second is to argue against the notion that every primary satisfaction is rational, and every secondary satisfaction irrational, by providing instances in which a normative theory might wish to deem irrational some primary satisfactions like urges to overeat, over drink and such like, and deem rational some secondary satisfactions like thankfulness, and ability to commit, eg Pope (1995), and thus to argue that there has been an irrational one-sided focus on the lure of compulsive gambling and other secondary satisfactions that most of us would deem irrational, and a failure to focus on the many primary satisfactions that are similarly irrational. The third way of showing

[1] Savage had by then radically altered his interpretation of EUT from that in Friedman and Savage (1948) which states that EUT omits secondary satisfactions and that this omission might be an empirical weakness.

the error in this widespread conviction that all secondary satisfactions are irrational is to take a closer look at the line of reasoning leading to the conclusion that they introduce contradictions into the choice theory, namely the appendix that von Neumann and Morgenstern added to their book in the 1947 edition. Von Neumann and Morgenstern added this appendix to deflect criticism that they had omitted secondary satisfactions and thereby kept to an excessively narrow risky choice theory. In this appendix they explained that their original intent had been to construct (and perhaps axiomatise) a broader decision model than expected utility theory. But von Neumann and Morgenstern pointed out (using the language of quantum physics) that secondary satisfactions involve a complementarity (or as we would say an interdependence) between mutually exclusive outcomes. For instance a positive secondary satisfaction such as an enjoyable thrill is happily feeling the tension that the two or more possible outcomes. But how can there be this tension, this interdependence von Neumann and Morgenstern asked when the outcomes are mutually exclusive? Such interdependence they said is a "contradiction" on the "level" of our theoretical framework. Von Neumann and Morgenstern stated it was such a "deep" problem to solve the contradiction and include the "elusive" secondary satisfactions, that they had to leave the task to future researchers (1947, pp628-32). Near the end of his life Morgenstern reiterated this joint desire of him and von Neumann, and their regret that the task had still not been accomplished.

### 2.4. *The Stages of Knowledge Ahead for Consistently Modelling Secondary Satisfactions*

Von Neumann and Morgenstern were correct in discerning that the contradiction was one of perception only, a problem of their framework not being at the right level for risky choice. What is required for risky choice is a minimum of a two period future at $t = 0$, the time of contract choice. The future must be divided at $t = 0$ into at least $P1$, a pre-outcome period of limited (merely probabilistic) knowledge ahead that lasts until the time $k$ when the risk about the outcome will be dissolved. From that time there ensues what may be termed $P2$, the post-outcome period of full knowledge ahead, of no uncertainty about the outcome, Pope (1983). Von Neumann and Morgenstern had sought only to axiomatise and model the simplest risky choice problems. But even for these there must be this minimum two period future. Without the pre-outcome period with the anticipated change in knowledge ahead at time $t = k$, there can be no risk.
The error in their framework had been to overlook this pre-outcome period, and thus include a false simultaneity postulate in their axioms. This error introduces the contradiction that the outcomes of sure contracts (those with the outcome known at $t = 0$), and risky contracts, those with the outcome unknown at this time, had their outcomes known simultaneously, Pope (1985). The error of omitting the pre-outcome period creates a corresponding timing fallacy in the definition of risky acts in EUT under which as in eg Harsanyi (1978), these are inconsistently defined as "probability mixes of sure acts".
What therefore is missing from most of contract theory at present is this division of the future into a risky immediate pre-outcome period of merely probabilistic knowledge ahead. All that EUT contract theory includes implicitly is the more distant future of the parties, the post-outcome period when all the risk will be past, when both will have full knowledge ahead.
Virtually all analyses and decision theories - even non expected utility theory ones - are

bereft of the risky pre-outcome period, and thus the parameter $k$, how long the chooser anticipates having only limited knowledge ahead of the outcome. The chooser has leapt over the risk and landed in certainty, eg the moments theory of Coombs and Huang (1970), the prospect theories of Kahneman and Tversky (1979), Tversky and Kahneman (1992), the disappointment and regret theories of Bell (1981, 1985), Loomes and Sugden (1982), the anticipated utility of Quiggin (1982, 1993), the aspiration-rank dependent theory of Lopes (1984), the prominence theory of Albers (2001), the priorities theory of Brandstätter et al. (2006).

To consistently include secondary satisfactions free of contradiction, contract theory - even non expected utility theory ones - must shift to a minimum of a two-period future divided by when at least one (and often each) party anticipates experiencing a change in knowledge ahead from merely probabilistic to full knowledge. In more complicated situations, limited knowledge ahead may not be in the form of numerical probabilities, there may be multiple anticipated changes in the degree of knowledge ahead, and thus multiple pre-outcome periods, and changes in degree of knowledge ahead may precede rather than coincide with changes in some of money that the parties receive.

Further some forms of secondary satisfactions involve earlier changes in knowledge ahead in the decision process. In this case we need to consider a series of time points $k_i$, $i = 1, 2, 3, \ldots$ at which there is a change in knowledge ahead. For instance, to suffer regret, or to get blamed or ridiculed for a bad outcome (such as having no money after a terrorist attack) is a consequence of an even earlier change in knowledge ahead. It is a consequence of the fact that there used to be the alternative for such persons of paying for protection, and that they chose not to do so. Such negative secondary satisfactions as blame (which as Hagen (1985) observed causes CEOs to be fired), arises out of there having been an earlier change in knowledge ahead, that from the pre decision situation, to a choice made on whether or not to buy insurance. Sauermann and Selten (1962), Simon (1991b), Selten (1998) emphasise implicitly even earlier changes in knowledge ahead, that from not knowing any available contracts to having negotiated at least one. This too will be relevant to our policy advice, namely the issue of the time and expenditure that governments and other insurers should expend in exploring and negotiating to create situations and associated contracts.

In Tables 1 and 2 we illustrate how including the pre-contract set identification, pre-decision and the pre-outcome periods (that von Neumann and Morgenstern inadvertently omitted) dissolves not only their contradiction but also related ones concerning secondary satisfactions during a succession of epistemic periods, that is during a succession of periods each demarcated from the earlier one by an anticipated change in knowledge ahead. Table 1 illustrates for an instance where the parties first need to explore and negotiate on what forms of contract are feasible. Then when this is known, it turns out that there is a single contract available and that the potential insurees need to decide at time point $t = 0$ whether to pay and take this contract that offers them full security of an asset of \$100. If they choose against the contract of paying for protection they face a pre outcome period of 24 hours during which the mutually exclusive outcomes of no attack and of an attack may be anticipated in their brains where they interact and may create negative secondary satisfactions of a) worrying whether or not an attack will occur, and b) being unable to commit to spend the money on things desired during these 24 hours.

By historical legacy that there used to be a pre-outcome period, and indeed a pre-

Table 1
Three Anticipated Changes in Knowledge Ahead $\Delta K_1, \Delta K_2$ and $\Delta K_3$ After Identifying the Risk of an Attack

| *Change* | *Time* | | *Knowledge with Respect to a Future or Past Event* |
|---|---|---|---|
| $\Delta K_1$ | from | before the choice set is identified | *Period* 1: only probabilistic knowledge of what the sub-acts search/negotiation in ascertaining and creating available contracts the insurers will identify as the feasible contract. |
| | to | contract, and risks without it, identified | *New epistemic period, Period 2 starts:* now know with a probability of 1 the choice set, ie sole contract available and what are the risks for those with property at risk who choose against the contract for protection against an attack. |
| $\Delta K_2$ | from | *pre-contract decision* | *Period* 2: only probabilistic knowledge about what the sub-acts of evaluating the contract will identify to each potential insuree on whether or not he or she will choose that contract, ie pay for protection. |
| | to | contract or not decided | *New epistemic period, Period 3 starts:* Parties know with a probability of 1 who chose the contract. |
| $\Delta K_3$ | from | *pre-outcome* | *Period* 3: lasting for $X$ hours in the case of those with property at risk who rejected the contract - choose not to pay for protection - only probabilistic knowledge of which outcome will be later learned to be the chosen act's *actual* outcome, whether *ie* the outcome will be \$100 or nothing<br>For those vulnerable to an attack who choose the contract - to pay for protection - this period is degenerated, of zero duration. |
| | to | *post-outcome* | *New epistemic period, Period 4 starts:* parties know with with a probability of 1 the chosen act's *actual* outcome.<br>For those whose property was liable to attack and who rejected the contract - choose not to pay for protection - the outcome is either \$100 or nothing.<br>For those whose property was liable to attack who chose the contract - to pay for protection - this period starts sooner, at $t = 0$, when they already know the outcome, namely \$85, \$100 minus the \$15 cost of protection to which they committed themselves. |

decision period when they could have chosen coverage, if in the future the outcome is the bad one of an attack, then in post-outcome period accusers can look back to the contract option and pour blame and ridicule on the person who earlier could have taken out insurance because of the previously possible mutually exclusive outcomes of choosing and not choosing a contract. Such ridicule and blame is infeasible, in contradiction with the facts, if there never was such a choice, never was such a pre-choice period in which to choose. Likewise the worry in the pre-outcome period is impossible, a contradiction in terms, if there never was a pre-outcome period, ie if the choose could have counterfactually leapt from choosing into the post outcome period without any intervening pre-outcome period. See Table 2.

## 3. Experiments

### 3.1. *Participants*

Participants comprised predominantly graduate students and faculty. They came from the University of Graz's Faculty of Economics and Social Sciences (located in Graz, Austria), and the University of Virginia's Darden Graduate School of Business Administration (located in Charlottesville, USA), and from its departments of Economics and Mathematics on the Charlottesville campus. For sex and academic status splits, see Table 3.

Table 2
Changing Knowledge Demarcating Eleven Sources of Secondary Satisfactions for the Uninsured

| Problem at time $t = -2$ | | *Anticipated Future* |
|---|---|---|
| ⇑ | 1 | Bad Stress eg time lost, expense of identifying relevant available acts |
| Pre-Choice Set period | | **and** |
| (*Available Acts unknown*) | 2 | Good Stress eg brain growth from challenge of identifying relevant available acts |
| ⇓ | | |
| Set identified at time $t = -1$ | | |
| ⇑ | 3 | Bad Stress eg time lost, expense of choosing |
| Pre-Decision period | | **and** |
| (*Act unknown* ) | 4 | Good Stress eg brain growth from challenge of choosing |
| ⇓ | | |
| decision at time $t = 0$ | | |
| | 5 | Fear, worry that one of the act's possible bad outcomes may come, |
| | | **and** |
| | 6 | Enjoyable Thrills as contemplate the alternative good and bad outcomes that may ensue |
| ⇑ | | **and** |
| Pre-Outcome period | 7 | Disadvantage of being unable to commit and thus enjoy the benefits of commitment |
| *(Act's outcome unknown)* | | such as ability to commit at $t = 0$ to repay a loan for a meal tonight |
| ⇓ | | **and** |
| | 8 | Disadvantage of being unable to plan efficiently, since do not know |
| | | whether future asset level would merit taking a friend out to dinner tonight |
| | | - this future asset level will only become known next period |
| Learn outcome at time $t = k$ | | |
| | 9 | Blame and Ridicule and Regret since rejected acts had better outcomes, |
| ⇑ | | **or** |
| Post-Outcome period | 10 | Praise and Admiration and Elation since rejected acts had worse outcomes |
| *(Act's outcome known)* | | **and** |
| ⇓ | 11 | Historical legacies, emotional and financial of the prior uncertainty |
| New problem at time $t > k$ | | |
| 1-8 help in this next pre-decision period, in making the next choice at $t = 3$. | | |
| We reason, choose partly through the emotions 1, 2, 3, 6 and 7. For instance brain damage removing the scope for 2 (fear) or for 7 (regret) removes good decision making, Damasio (1984), Camille et al. (2004). | | |

### 3.2. *The Scenario: Potential Monetary Payoffs*

Participants were handed a sheet on the context. This asked them to state whether they would take out protection insurance against an attack which would annihilate a sum available to them later. Later was about 24 hours later in the case of the first two

Table 3
Number of Participants by Sex and Academic Status

| | Female | Male | Total |
|---|---|---|---|
| Faculty | 2 | 12 | 13 |
| Doctoral Students | 8 | 10 | 18 |
| MBA students | 4 | 36 | 40 |
| Undergraduate students | 18 | 23 | 41 |
| Total | 32 | 81 | 113 |

Graz sessions. In the case of the Charlottesville Session, about two hours later.
The sum subject to attack was fixed in each session, at a sum of €80 (€:EUR) in the case of the four Graz experiments, and of $100 ($:USD) in the case of the Charlottesville experiment. At the USD/EUR exchange rate of March 2004, these amounts are roughly comparable. We can merely state that the amount at risk is more than a trifle, but well short of that which would endanger the financial viability of participants.
The cost of protection insurance was fixed in each session, at a cost of €30 in the first two Graz sessions, at $15 in the Charlottesville session, and at €12 in the last two Graz sessions. In all sessions participants were asked to indicate whether they would take out insurance at this cost. They were asked to make their choice six times, for six different alternative levels of risk, namely 0.1%, 0.2%, 1%, 5%, 10% and 20%. The risks were first described in terms of the number of days in which there had been an attack in the last 1,000. Then the corresponding percentages were given.
In all sessions, participants knew prior to choosing their potential monetary outcome as follows. Each would place his or her name on a piece of paper in a box. After the answers to all questions had been collected, the papers containing the names would be shuffled in a box in front of the class by one of the experimenters. In front of the group, one participant would then select one paper from the shuffled box and read out the name. The experimenters would then confirm from the collected written answers for what risk levels the selected participant had chosen to pay insurance money. If the one selected had chosen to pay insurance for all six risk levels, that participant already knew at the end of the session the monetary sum to be received. If instead the selected participant had merely insured for some or none of the risk levels he or she would write the six levels of risk on pieces of paper and place them in a box. These six pieces of paper would then be shuffled by one of the experimenters, after which the selected participant would draw one paper out, give it to one of the experimenters who would then read out its risk level in front of all participants. Later, at the end of the whole experimental session, in the presence of all participants, the selected one would discover from a random device whether an attack had occurred.
Our experimental method of analyzing responses to the risk of an attack and loss of an asset is subject to two (standard) laboratory problems. First, participants may deem the probabilities smaller than those stated because they both have a smaller chance of any particular risk level being realized and a smaller probability of being the participant selected to receive the monetary consequences of the choices made. Amongst our participants, only 2% reported being subject to this effect, results consonant with the decisions in control experiments not subject to these probability diminutions reported

in Starmer and Sugden (1991). A second problem is that our design does not put participants who choose not to commit to pay for insurance in the situation of walking out of the experiment with less assets than on entering it, merely at risk of missing out on an amount that they could have gained in the experiment. Amongst our participants only 4% of participants reported that their decision would have been different if subject to being at risk of losing pre-existing assets as distinct from at risk of missing out on an increment in assets. Thus neither problem appears to be substantial. Moreover our experimental method for discerning the motivators of choice and how distinct motivators are employed in choosing among acts is substantially independent of the absolute scale of the probabilities and the extent to which behaviour differs with respect to the risk of missing out on potential gains versus losses.

### 3.3. *Method*

The main investigatory technique employed has accordingly been to have participants explain why, for each of the six risk levels, they chose to either avoid or assume the risk of an attack. They had the opportunity to alter their choices while stating why they chose. This is because their choices and the reasons they stated were collected simultaneously (written respectively on the front and back of a single sheet). In cases where they chose to insure, they were asked to indicate if their reason was:

1. to avoid worry that in an attack they would lose it all and/or
2. \$85 is far better than \$0, but \$100 is only a little better than \$85 and/or
3. other reasons, with a please explain these.

In cases where they chose to bear the risk, they were asked to indicate if their reason was:

4. to enjoy the thrill that there might be an attack where I would lose all and/or
5. \$85 is only slightly better than \$0, but \$100 is far better than \$85 and/or
6. other reasons, with a please explain these.

In the Charlottesville session additional questions were asked after the first set had been collected, questions 7 and 9 enticing them further to indicate use a rank dependent method of evaluation of acts, questions 8 and 10-11 on hypothetical situations, as follows.

In those circumstances in which you chose to pay for protection,

7. was a consideration behind your decision a greater weight than indicated by the simple probability weight for the utility from the bad outcome of an attack? If the answer is yes, explain how you weight the alternative possible good and bad outcomes.
8. would you have paid the \$15 for protection money if you had to pay it up front, in which case you would receive \$100 for sure later this afternoon?

In those circumstances in which you chose to not pay for protection,

9. was a consideration behind your decision a greater weight than indicated by the simple probability weight for the utility from the good outcome of no attack ? If the answer is yes, explain how you weight the alternative possible good and bad outcomes.
10. would you instead have paid for protection if tonight were the only night when you could take a special friend out to dinner that would mean a lot to you but which you could not afford to do unless you knew that tomorrow you would be at least

$85 richer than you are today?

11. would you instead have paid for protection if you wished to borrow money from a friend for a meal out tonight, and knew that this friend would not lend you any more money today unless you could guarantee to repay it tomorrow?
12. would you instead have paid for protection if a friend or colleague would ridicule or blame you if they discovered later that you had not paid, that there was an attack and that you had missed out on $85?

## 4. Findings on Motivations and Choice Procedures

### 4.1. *Choices Made*

Our choice set-up has the same cost of protection for all six alternative risk levels. It resulted in nearly all participants exhibiting a threshold risk level. Such threshold participants bought protection at all risks higher than this threshold, at no risk level below it. For 30% this threshold was never reached: they never insured. For 10% this threshold was a lower risk than 0.1%: they insured for every risk level. The remaining 6% (seven participants, one in session 1, one in session 3, one in session 4, and four in session 5) displayed non-monotonic behaviour of insuring at a lower risk level, but not at higher risk levels. Six of these seven were undergraduates. Such decisions may be due to capriciousness as reported in Abbink et al. (1999), namely participants seeking to deviate sometimes from their general behaviour in the face of risk, so that if they have been daring for a succession of possible eventualities, for the next in the succession, they are cautious (and vice-versa). We did not include a question inquiring into capriciousness. Hence we cannot check whether this non-monotonic behaviour is instead be due to misinterpreting how to enter choices, or misinterpreting the choices available. We excluded from the analysis therefore this 4% of our original sample, reducing it from 113 to 106.
Table 4 summarises the monotonic insurance decisions of the other 94% of participants. No systematic effects of sex or wealth as proxied by academic status are discernible by eye or using Fisher's exact tests. It can be seen that the cost of insurance (roughly double in the first two sessions compared to the latter three) had no obvious systematic impact on insurance decisions. The inter-session differences in propensities to pay appear to be related more to context.

### 4.2. *Secondary satisfactions*

These are summarised in Table 5 below. Around 20% of non-undergraduates gave the secondary dissatisfaction of worry as a motivator for choosing the protection contract, and of these the majority gave avoiding this negative secondary satisfaction as their sole motivators for taking the contract, in all three population groups. For only 3% of undergraduates was this the case. The difference is weakly significant on Fisher's exact two-tailed test, at the 10% level, and for those who hold the prior hypothesis of undergraduates being carefree, significant at the 5% level.
The positive secondary satisfaction of enjoyable excitement was a motivator for choosing the protection contract in the case of nearly 30% of participants in the Graz sessions, with the majority of these giving this positive secondary satisfaction as their sole motivators

Table 4
Insurance Decisions

| Session | Highest Percentage Risk for which Insured | | | | | | Percentage Uninsured at all Risk Levels | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 10 | 5 | 1 | 0.2 | 0.1 | female | male | faculty plus‡ | doctoral students | MBA students | Under-graduate | Total |
| 1 | 1 | 0 | 2 | 1 | 0 | 1 | 21 | 43 | 36 | na | 0 | na | 64 |
| 2 | 3 | 3 | 4 | 3 | 0 | 3 | 0 | 22 | na | 22 | na | na | 22 |
| 3 | 21 | 4 | 8 | 2 | 2 | 2 | 0 | 5 | 0 | na | 5 | na | 6 |
| 4 | 2 | 3 | 0 | 2 | 0 | 2 | 26 | 26 | na | na | na | 53 | 53 |
| 5 | 4 | 0 | 0 | 2 | 2 | 2 | 7 | 43 | na | na | na | 50 | 50 |
| 4+5 | 4 | 5 | 1 | 0 | 0 | 6 | 43 | 58 | na | na | na | 52 | 52 |
| 1+2+4+5 | 9 | 8 | 7 | 2 | 0 | 9 | 35 | 54 | 63 | 22 | 67 | 52 | 46 |

for not taking out protection contracts. Perhaps because of reference to terrorism as the context of the attack in the pre-advertisement of the Charlottesville session, this attraction to chance in the terrorism context was not shared by that group where less than 5% nominated enjoyable excitement as a motivator for not paying for protection. This difference is significant under a 2-tailed Fisher's exact test well in excess of the 1% level.

Consider now the counterfactual questions 10, 11 and 12 asked in sessions 3, 4 and 5, on three other secondary satisfactions. Questions 10 and 11 respectively introduced the scope for two instances of negative secondary satisfactions from being unable to commit and efficiently intertemporally allocate their consumption flow. The vast majority answered yes when confronted these consumption allocation inefficiencies: over 80% when it was being unable to commit to taking a special friend out to dinner, question 11, and over 70% when it was being unable to commit to repay for a meal for oneself, question 10. Question 12 introduced the scope for the negative secondary satisfaction of ridicule or blame in the event an attack and being uninsured. Over 20% stated that they would pay for protection if they anticipated such ridicule or blame ensuing.

In all five sessions, those indicating secondary satisfactions as a motivator for choice was nearly 80%. In all in the three sessions in which we asked participants about not merely two, but five instances of secondary satisfactions, over 95% gave secondary satisfactions from secondary satisfactions as a motivator for choosing whether or not to take out a protection contract. This in turn meant that the 99% confidence limit for the lower bound of the population proportion influenced by any of the above secondary satisfactions is 0.85, calculated using the exact binomial distribution. In turn, this lower bound will be an understatement of the percentage ever influenced by any secondary satisfaction in their choice. It is the lower bound for choice sets in which merely five distinct instances of secondary satisfactions were listed.

Table 5
Secondary Satisfactions: Influences on Decision to Pay or Not Pay for Protection

| Specific Positive or Negative Secondary Satisfaction | Percentage reporting this as a Motivator for Choice | | | | | | |
|---|---|---|---|---|---|---|---|
| | females | males | faculty | doctoral students | MBA students | under-graduate | Total |
| *Reasons for Paying for Protection* | | | | | | | |
| *To avoid a negative satisfaction* | | | | | | | |
| Q1 worrying whether there will be an attack | | | | | | | |
| sessions 1+2 | 8 | 25 | 38 | 17 | 0 | 0 | 19 |
| session 3 | 50 | 21 | 0 | na | 25 | na | 22 |
| sessions 4+5 | 0 | 5 | na | na | na | 3 | 3 |
| Q12 ridicule/blame for uninsured in an attack* | | | | | | | |
| session 3 | 67 | 17 | 25 | na | 21 | na | 21 |
| sessions 4+5 | 21 | 32 | na | na | na | 27 | 27 |
| sessions 3+4+5 | 29 | 22 | 25 | na | 21 | 27 | 24 |
| *To reap a positive satisfaction* | | | | | | | |
| Q10 ability to commit for dinner with friend* | | | | | | | |
| session 3 | 67 | 91 | 100 | na | 88 | na | 89 |
| sessions 4+5 | 64 | 79 | na | na | na | 73 | 73 |
| Q11 ability to commit to repay for own dinner* | | | | | | | |
| session 3 | 67 | 77 | 75 | na | 76 | na | 76 |
| sessions 4+5 | 71 | 63 | na | na | na | 67 | 67 |
| *Reasons for Not Paying for Protection* | | | | | | | |
| Q4 thrills/wondering about an attack | | | | | | | |
| sessions 1+2 | 25 | 30 | 13 | 28 | 33 | 67 | 28 |
| session 3 | 0 | 6 | 0 | na | 6 | na | 6 |
| sessions 4+5 | 29 | 32 | na | na | na | 30 | 30 |
| sessions 1+2+3+4+5 | 25 | 19 | 8 | 28 | 9 | 33 | 21 |
| Worry or Thrills (sessions 1 and 2) | 33 | 50 | 50 | 39 | 33 | 67 | |
| Any of the Above Secondary Satisfactions (all sessions) | 71 | 82 | 67 | 39 | 91 | 92 | 79 |
| Any of the Above Secondary Satisfactions (sessions 3, 4 and 5) | 100 | 94 | 100 | na | 97 | 94 | 96 |

* Only sessions 3 (faculty and MBAs), and 4 and 5 (undergraduates) were asked questions 10, 11 and 12

### 4.3. *Expected Utility Theory Disobeyed*

Nearly 80% of our participants are found to be influenced by secondary satisfactions and thereby disobey EUT, ie those who checked any of questions 1, 3, or (in the case of the latter three sessions) 10, 11 and 12. For the about one fifth of our participants not detected to be influenced by secondary satisfactions under our investigative meth-

ods, there are other requirements that need to be met before we can conclude that this fifth makes choices predictable under EUT. There needs to be a consistency with EUT of each such participant's answers under Questions 2 and / or 3 for any circumstances under which each such participant decided on a protection contract, and a lack of discrepancy with the implied utility function in their answers under Questions 5 and / or 6 for those circumstances in which such a participant decided against a protection contract. Two participants for instance checked both Questions 2 and 5. This is reasonable if for each the satisfaction from each of the three asset levels is based on the probability of that asset level occurring, ie on the participant's different degree of knowledge ahead that he would encounter in the low and high risk circumstances associated with when he did and did not choose the contract. But checking both these questions is incompatible with EUT since it implies conflicting shapes for its independent of knowledge ahead utility function.

Again, EUT is not simply a matter of looking only at the shape of the utility function and ignoring the probability of occurrence of each outcome. Consistency with EUT is therefore likewise violated by those participants who checked Question 2 but did not check Question 3. To conform with EUT, they needed to check question 3 and state either their complete valuation formula, or at least mention that they formed their overall valuation of the risky act not to take a protection contract as inferior to the sure act of taking the insurance contract as follows. They added up their mutually exclusive utilities under this rejected risky alternative by multiplying the probability of no attack by the utility of receiving the full sum and comparing this with the utility of the guaranteed. (If they did not impute to the zero outcome a zero utility, they also needed to mention multiplying the zero outcome by its probability and adding this on to get the overall value.) Yet no participant who checked Question 2 offered such an account in Question 3. Indeed nearly all who checked Question 2 left Question 3 blank, suggesting rather that they employed a single attribute procedure in choice.

Again, EUT is not simply a matter of paying for protection if probabilities of attack are higher, not paying for it if the probabilities of attack lie below some threshold. EUT involves the chooser comparing the probability weighted sum of utilities under higher and lower probabilities. Those therefore who checked Question 2 as the ground for insurance, should also have checked Question 3. In Question 3 they needed to explain either how the shape of their utility function was not so concave as to cause them to choose the contract at low probabilities, or else how they used all the individual axioms in an EUT axiomatisation to reach their conclusion. None of them did this however.

There were only 3 out of 101 participants who conformed with EUT in their answers. These were participants whose sole basis of choice was expected value, the special case in which EUT's independent of knowledge ahead utility function is linear. It is reasonable to assert that rather few of these three would conform in more complex realistic attack or terror contexts with larger sums at stake.

This is because our laboratory set-up was specially designed to make EUT easy to obey. The set of monetary outcomes was known precisely, as was the set of associated probabilities and each of these involved only one significant digit. There was moreover for each act at most one outcome with a positive probability, and that outcome contained at most two digits.

This set-up does two things. One is to render it feasible for the even fractionally arithmetically competent to compute expected values: only one product in each case, and

then only multiplying a single number by at most a two digit one.
The other and much more important thing that such a set-up does is to relieve participants of needing to ponder how much they might have at risk or the risk of attack. These we specified for them. In actuality the numerical risks are missing from the insurance contract, something those choosing to accept the contract are assumed under EUT to be able to figure out for themselves.
The difficulty for even eminent businessmen and scientists to construct a) their outcome space and b) a probability distribution over it may be judged in three ways. First, the observations of that keen observer of businessmen, Knight (1933) contended that business profits came from the difficulty of judging both a) and b), Langlois and Cosgel (1993). Second, experimental evidence supports Knight on the inability to formulate consistent probability distributions over outcomes and to furnish consistent utilities to individual outcomes, Borcherding and von Winterfeldt (1988); Borcherding et al. (1991, 1995). Third, even the eminent attempt of Savage (1954) to offer axioms consistent with chooser's judging a) and b) while obeying EUT failed. His axiomatisation yields arbitrary results, so that it is only last year that success has been achieved in offering a feasible means of doing so (see Karni (2006)) though whether even Karni has succeeded is disputed by many. It is reasonable to say therefore that in the actual more complex realm under which protection contracts against terrorism are offered, not even those three participants, that third of one percent, will choose obeying expected utility theory.

### 4.4. *All Rank Dependent Theories Disobeyed*

There is a notion that while expected utility theory is disobeyed, all that is needed to obtain a good descriptive and predictive theory is the generalisation of its rule that mutually exclusive possible utilities be weighted by their probabilities of occurrence as permitted under standard rank dependent theories and as proposed in Allais (1952). Examples of how to do the generalisation of the (de)cumulative probability weights are Quiggin's anticipated utility (1982), Lopes' theory of attention to upper and lower bound outcomes (1984, 1986), the Allais rank dependent theory (1986) and the cumulative prospect theory of Tversky and Kahneman (1992).
This whole class of theories retains two features of expected utility theory. First the values of outcomes are assumed to stem exclusively from anticipated primary satisfactions, ignoring all anticipated secondary satisfactions. In this regard the entire class of standard rank dependent theories is disobeyed by some four fifths of our participants. These are the four fifths who reported being influenced even by the narrow range of secondary satisfactions introduced above.
Second all rank dependent theories share with EUT its procedure of forming an overall valuation of each act by forming (decumulative) probability weighted sums of the primary satisfactions obtained from the outcomes. None on the answers proffered by our participants to the first set of questions gave any indication of participants using even EUT's simple probability weights except when that theory is simplified down to linear primary satisfactions in money. Such persons refuse unfair insurance contracts. And since those furnishing protection normally have costs, if the demand for insurance were limited to those with linear primary satisfactions in money, there would normally be no insurance companies and long run financial nonviability for governments providing

terror protection or any other sort of insurance. The financial viability of most insurance arrangements and the desirability of issuing insurance contracts, pertains to demand for "unfair" insurance.

Nevertheless we deemed it desirable to investigate further whether the demand for protection contracts at unfair rates might arise from protection purchasers computing (decumulative) probability weighted sums of satisfactions from alternative possible utilities, ie whether simple EUT or with a more complicated set of weights as in its rank dependent generalisations applied. Questions 7 and 9 added to the Charlottesville session, do this. Of the very few who checked either Question 7 or 9, most explanations of why they checked these answers were unrelated to rank dependent probability weighting. Only two participants, five per cent of this session, gave corroborating accounts, one was broadly in accord with that of the Quiggin rank dependent theory for when no protection contract was taken, and one was broadly in accord with the Lopes rank dependent theory of how the probability weights are formed for when an insurance contract was taken. But both participants disobeyed these particular rank dependent theories since: 1, neither gave attention to these special probability weights when they took reverse decisions on whether to take a contract (each checked only one of 7 or 9, despite both choosing the protection contract in some circumstances, not in others; and 2) both reported being influenced by secondary satisfactions. This suggests that for a tiny minority, a rank dependent theory might be pertinent to contract if generalised to: a) be activated only at one end of the distribution, and b) include secondary satisfactions. But for the overwhelming majority of participants, rank dependent theories shed no light on the demand for protection contracts.

## 5. Choice Procedures

When all the numbers are simple and at hand, some participants engaged in multiplication of primary satisfactions (measured by net monetary outcomes) with their probabilities and compared this magnitude with that of another operation, subtracting from the gainable sum the cost of protection. This expected net value calculation, was performed by 16 of the 101 participants in all, predominantly by those in the Charlottesville group. Since this was one of the three experiments in which the cost of protection was below the expected gross return on insuring, the propensity of this group to use expected value may account for the exceptionally high number of Charlottesville participants insuring for at least one risk level. No participant in sessions 4 or 5, which likewise had a low enough cost of protection to warrant insuring at the 20% risk level, used an expected value criterion.

Of the 16 who used expected value, however, only three reported doing such a set of calculations and comparisons as their sole criteria on whether to take out a protection contract. Virtually all reported being swayed, in many cases decisively, by secondary satisfactions. None swayed by secondary satisfactions reported that they had used or would use a formal procedure for adding up all the primary and secondary satisfactions and other considerations into a single index for each of their two available acts, to take or not take out a protection contract under the six alternative levels of risk. This was likewise the case as regards integration of all the other considerations that sizable percentages of participants listed as swaying their choices, namely:

(i) the increment in value of the amount possibly receivable over that guaranteed by paying for protection (ie those who checked questions 2 or 5 concerning the utility shape): 50% of participants,
(ii) the probability of an attack: 26% of participants,
(iii) the cost of protection: 17%,
(iv) the amount at risk: 9%.

Thus our experimental evidence accords with contracts being decided upon by looking at a set of distinct factors anticipated to yield positive or negative satisfactions. Some participants integrate these conflicting negative and positive satisfactions, eg all who used expected net value criteria. These participants integrated the full amount attainable with its cost. Under the risky act of not paying for protection, they integrated its good outcome with its probability of occurring (in the form of multiplying these two together). Yet even here it is to be noted that despite some being acquainted with expected utility theory, employing it in conjunction with a non-linear utility function was apparently too complex for any to use EUT as their basis for contract choice.

But for the majority of our participants what integration there is of conflicting goals is apparently less of a calculating procedure. This lack of multiplication and addition of numbers runs counter to EUT, to most of its rank dependent generalisations. The Albers prominence theory (2000) contributes handsomely on the role of choice sets in how fine are the numerical distinctions that we introduce into our decision processes. But is also involves multiplication and addition of numbers for which we find no evidence.

Nearly all our participants seem to be non numerical in what integration they do of the distinct sources of primary and secondary satisfactions arising out of the set of mutually exclusive possible outcomes of a risky act. Nearly all our participants, any integration done of distinct sources of satisfactions and of mutually exclusive possibilities is qualitative not qualitative. Participants do not mention whether comparisons take the form of subtractions or ratios.

When distinct satisfactions are not systematically integrated into overall indices of the valuation of whether or not to take out a contract, some other rule is needed to reach a decision and stop searching further for the best thing to do. That proposed by Simon (1955) in general terms has been made more concrete in the aspiration adaptation models of Sauermann and Selten (1962) and Selten (1998), and in the take-the-best models of Gigerenzer (2003) and Brandstätter et al. (2006). Our experimental results suggest that these sequential non integrating approaches are promising.

The particular priorities highlighted by our participants in our particular context of an attack gives a more prominent role to the probability of the bad outcome (an attack and losing all) than to the outcome that is worse by more than 10% relative to the next worst outcome (committing to insure and paying the cost). This conflicts with the priorities identified in identified in Brandstätter et al. (2006) for a different gamut of choice sets, contexts and framings. As Brandstätter mentioned to us in an email, this is likely due to the prominence of six different risk levels in our particular attack choice sets. Albers has demonstrated that choosers have rather less of the fixed check list and set of priorities proposed in the Selten-Gigerenzer-Brandstaetter models in reaching choices.

In setting their priorities choosers have a sensitivity to choice sets, contexts and framings. We humans are quite unable to envisage the huge number of ramifications of an act and thus rely on choice sets, contexts and framings to bring considerations into our imagination. Decision scientists unconsciously frame choice sets, contexts and framings

in ways that make primary satisfactions salient to choosers and secondary satisfactions non-salient because outside the EUT lens that so heavily influences their perception. The consequence is an unintended difficulty in 1, perceiving the prominent role of secondary satisfactions in actual choices; and 2, the dependence of priority heuristics on choice sets, contexts and framings.

Our findings demonstrate however that economists and psychologists, even those seeking new more realistic decision theories, have concentrated on rather too narrow a set of choice sets, contexts and framing to discern the lack of universality of any (practical) decision theory and the readiness of decision makers to be swayed by factors drawn to their attention. In turn this means that in deciding on protection contracts, people are vulnerable / open to suggestions on the part of outside bodies that can tilt their decisions on a contract.

## 6. Conclusion

Our findings disconfirm two widespread assumptions. One is that favoured in economics of EUT choosers with so-called constant relative risk aversion (involving a concave "as if certain" mapping from outcomes into utilities). The other is that favoured in finance of EUT choosers with so-called risk neutrality (involving a linear "as if certain" mapping from outcomes into utilities).

EUT and other standard rank dependent theories such as cumulative prospect theory have here been shown to be undesirably narrow in considering only what are here termed primary satisfactions, namely satisfactions that are independent of knowledge ahead. Replacing the inherently static framework of these theories with an evolving stage of knowledge ahead framework would include decision makers' reasonable desire to take into account secondary satisfactions pertaining to the emotions and inter-temporal resource allocation both of which depend on the anticipated evolution in knowledge ahead.

EUT and other standard rank dependent theories have here been shown to assume more integrative arithmetically complicated procedures than that employed by actual decision makers. Only five percent of our participants employ the usage of integrated quantitative aggregation rules for evaluating acts as assumed under EUT and all standard rank dependent theories. The overwhelming majority use piecemeal algorithmic approaches. The heuristics employed vary, we show, with the frame and decision context.

Both therefore as regards usage made of different sources of satisfactions in reaching a decision and as regards the range of sources of satisfactions considered, it is desirable to move outside the basically static mechanical and context free universalist presumptions of EUT and other rank dependent theories. We have indicated how an appreciation of the fundamental role of anticipating a change in knowledge ahead can allow scientists to consistently investigate all major sources of satisfactions, secondary as well as primary. We have indicated how to frame and enrich theories and experimental set-ups so as to elicit the information required to develop an understanding of the range of satisfactions that do and should enter the decision procedure for reasonable people. Doing so may open the way for scientists to develop deeper the applications of these principles in insurance and other contexts. This may then enable pertinent empirical work to identify the quantitative significance of different primary and secondary satisfactions, and the popularity of different algorithmic decision procedure in each particular context. These developments

in turn may afford decision scientists insights for better describing and predicting how people chose, and for a better grasp of normative issues and thus of prescribing how people should choose.

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