Judgment, Communication and Decisions Under Uncertainty: A Psychological Perspective

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IMAGE TOY: Uncertainty in Climate Change Research: An Integrated Approach

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Overview

- Why is the psychological perspective relevant to the CC community?
- Some background and terminology
- Judgment of uncertainty (probability)
- Combining probabilities
- Judge – DM interaction and communication
- Individual decision making under uncertainty and with imprecise information
- Group decision making (Social dilemmas) under uncertainty

Why is the psychological perspective relevant?

- To turn science into action, the models' results (forecasts, estimates and the corresponding uncertainties) need to be communicated to the public, stakeholders and DMs who do not necessarily understand the science, the model and the process
- Sometimes the models depend on subjective probabilities (parameters, outcomes, etc.) that must be elicited from experts or stakeholders)
- Introspection and insight– learn about one's own tendencies, biases, etc

Background and terminology

Behavioral Work in J/DM

- Empirical (mostly experimental) research on the way DMs (individuals, small interacting groups) make decisions
- Normative (axiomatic) – models of the *decision problem*
- Descriptive (behavioral) – models of the *decision maker*
- Phenomenon (data) driven

Probability in Psychological Studies

- The three interpretations of probability
  - Classical (Laplace)
  - Relative Frequency (Von Mises, Reichenbach): ***The*** *probability of E is…*
  - Subjective/Personal (Ramsey, De Finetti, Savage): ***My*** *probability of E is…*
- The three approaches are not always differentiated and are often used interchangeably
- This has been an area of (sometimes heated) theoretical disagreements

Variants of Uncertainty (K&T,1982)

- External to the judge (Aleatory)
  - Distributional (“Outside” view)
  - Singular (“Inside” view)
- Internal to the judge (Epistemic)
  - Reasoned (Arguments)
  - Direct (Experience)
- These are useful as special cases but the classification is subjective and, often, ambiguous

Sources of Imprecision in Communication of Uncertainty (Budescu & Wallsten 1995)

- *Nature of the event:* An event is ***unambiguous (ambiguous)*** if its definition allows one to determine unequivocally if any given outcome is (is not) an exemplar of the target event.
- *Type of uncertainty underlying the event*: Uncertainty is ***precise*** is it can be expressed by means of a proper probability function, and it is ***vague*** if such a function cannot be specified.
- *Language of communication:* Numerical probabilities are the language of the ***precise communication***, whereas intervals (*e.g. 0.2 – 0.4*), qualified values (*e.g. around 0.6*), and linguistic probabilities (*e.g. highly likely*) are examples of ***imprecise ones***.

Judgment of probability

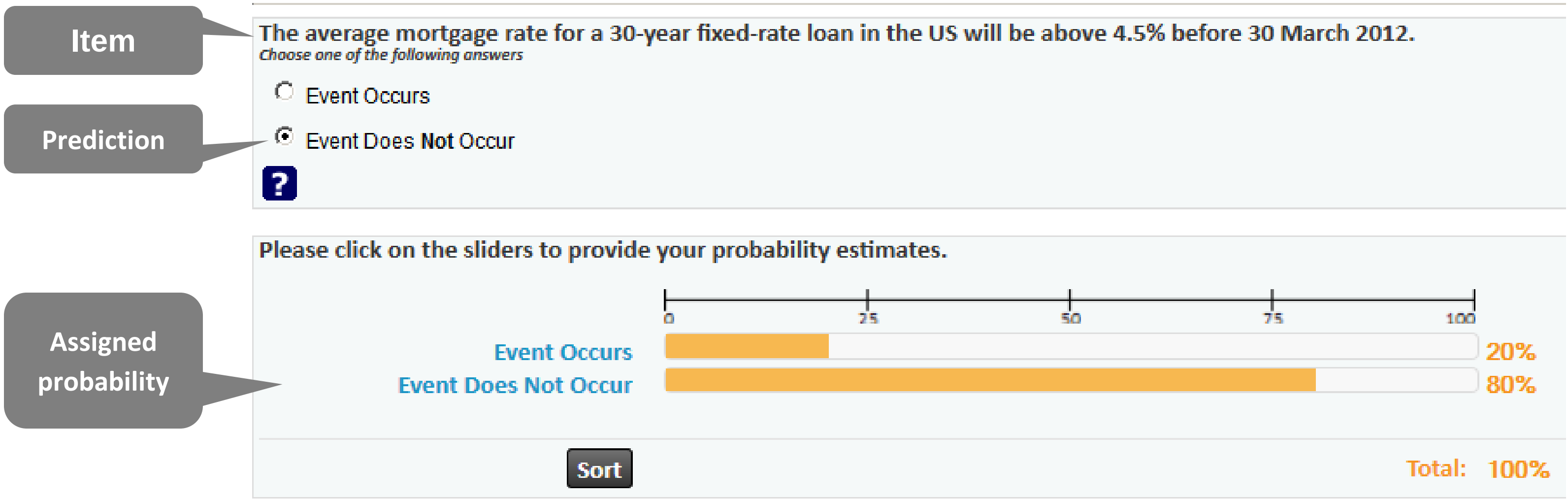
Types of Probabilities Judged

(Lichtenstein, Fischhoff, Phillips, 1982)

- Discrete events
  - Single target event & full range
  - C (C $\geq$ 2) alternatives & 1/C range
- Continuous events (full distributions)
  - Fixed Value
  - Fixed Probability

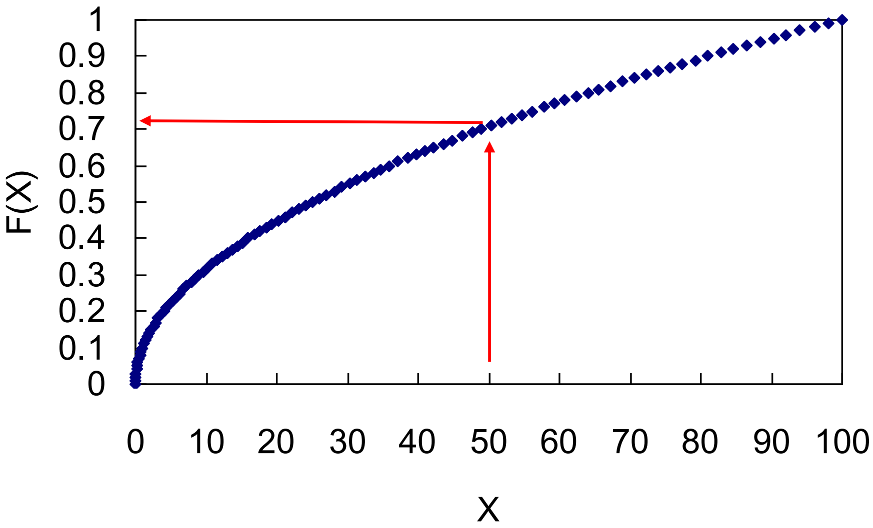
- Direct and indirect methods
- Most of the work on discrete events (full or half range) and direct estimation

www.forecastingace.com

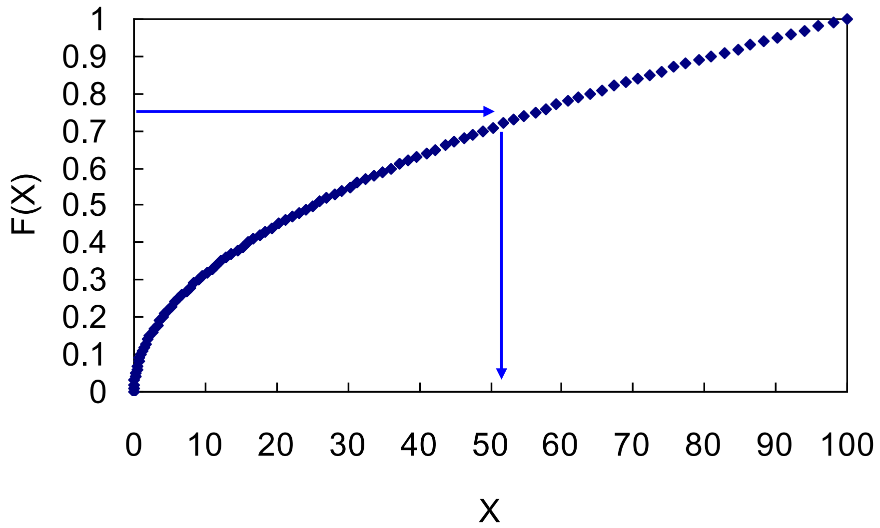


- Started in July 2011 and will continue for several years.
- Collects forecasts from voluntary judges
- Items from business, economy, military, policy, politics, social, sports, health, science and technology, etc.

FP and FV



F(X)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 10 20 30 40 50 60 70 80 90 100
X



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0.2
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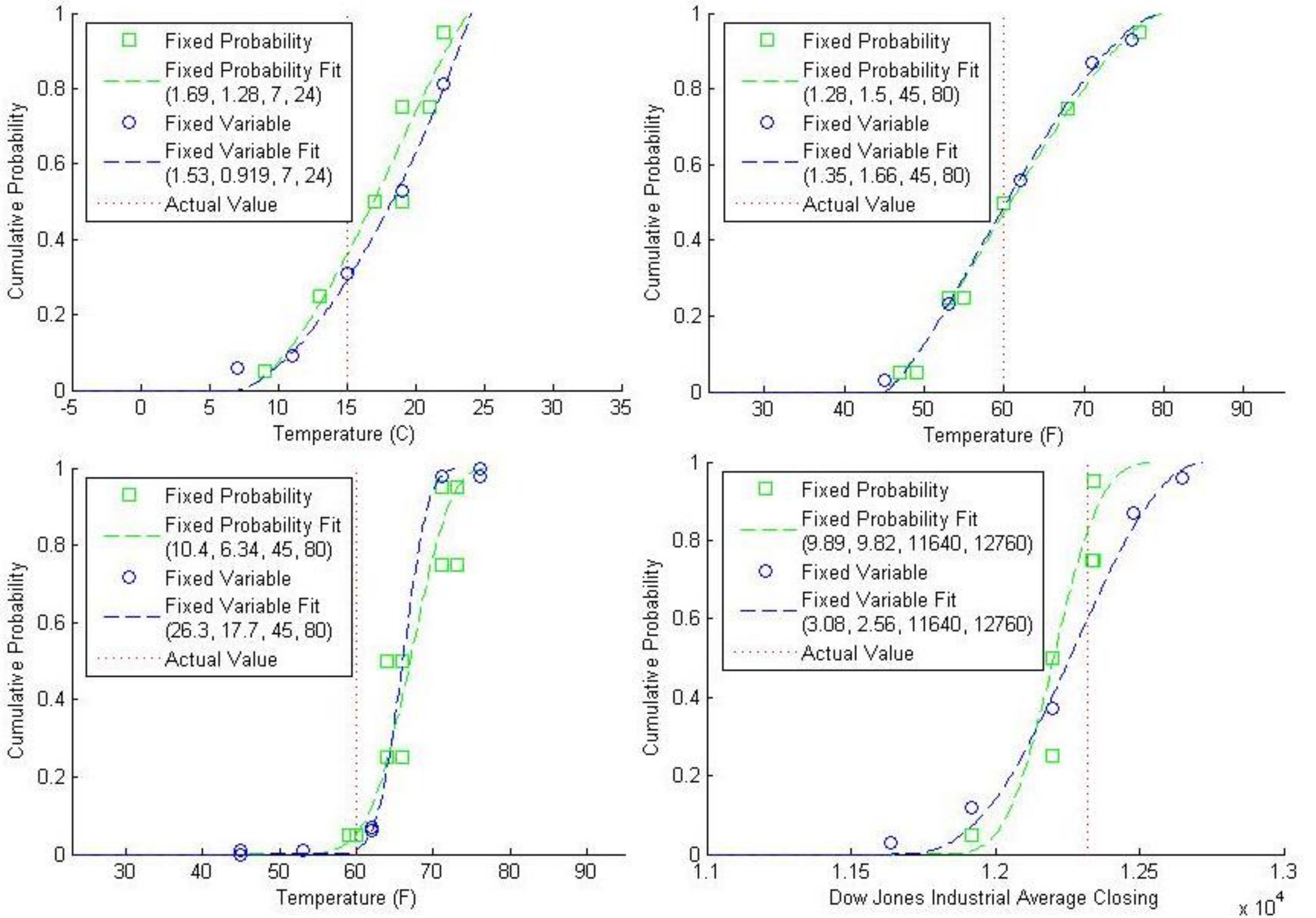
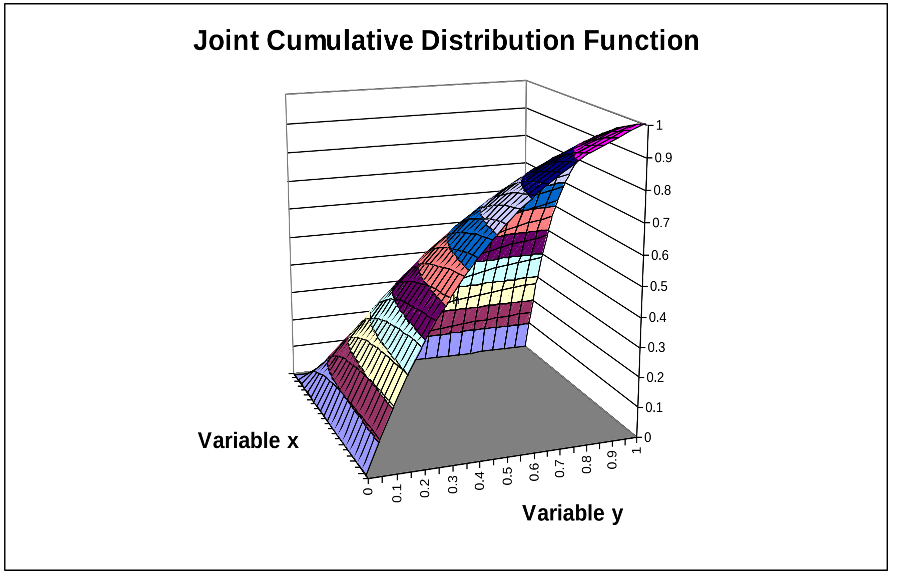
0
0 10 20 30 40 50 60 70 80 90 100
X

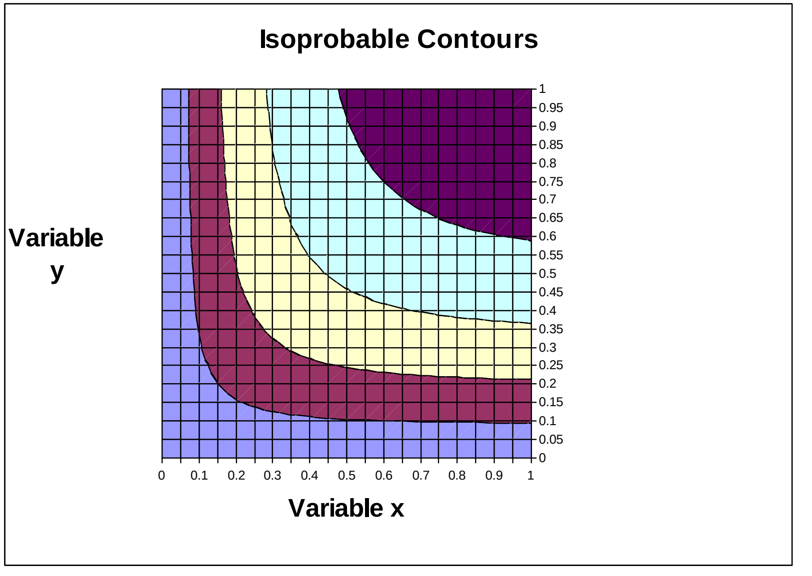
Indirect Method (Abbas, Budescu et al. 2007)

Examples of Distributions (Abbas, Budescu et al. 2007)



Assessing Joint Probabilities (Abbas, Budescu, Gu, 2010)





Assessing Joint Probabilities (Abbas, Budescu, Gu, 2010)

You win $20 if

<6'1''

and

<148 lbs

the height of a randomly selected UIUC male undergraduate student is less than 6'1'' and his weight is less than 148 lbs

<6'2''

and

<112 lbs

the height of a randomly selected UIUC male undergraduate student is less than 6'2'' and his weight is less than 112 lbs

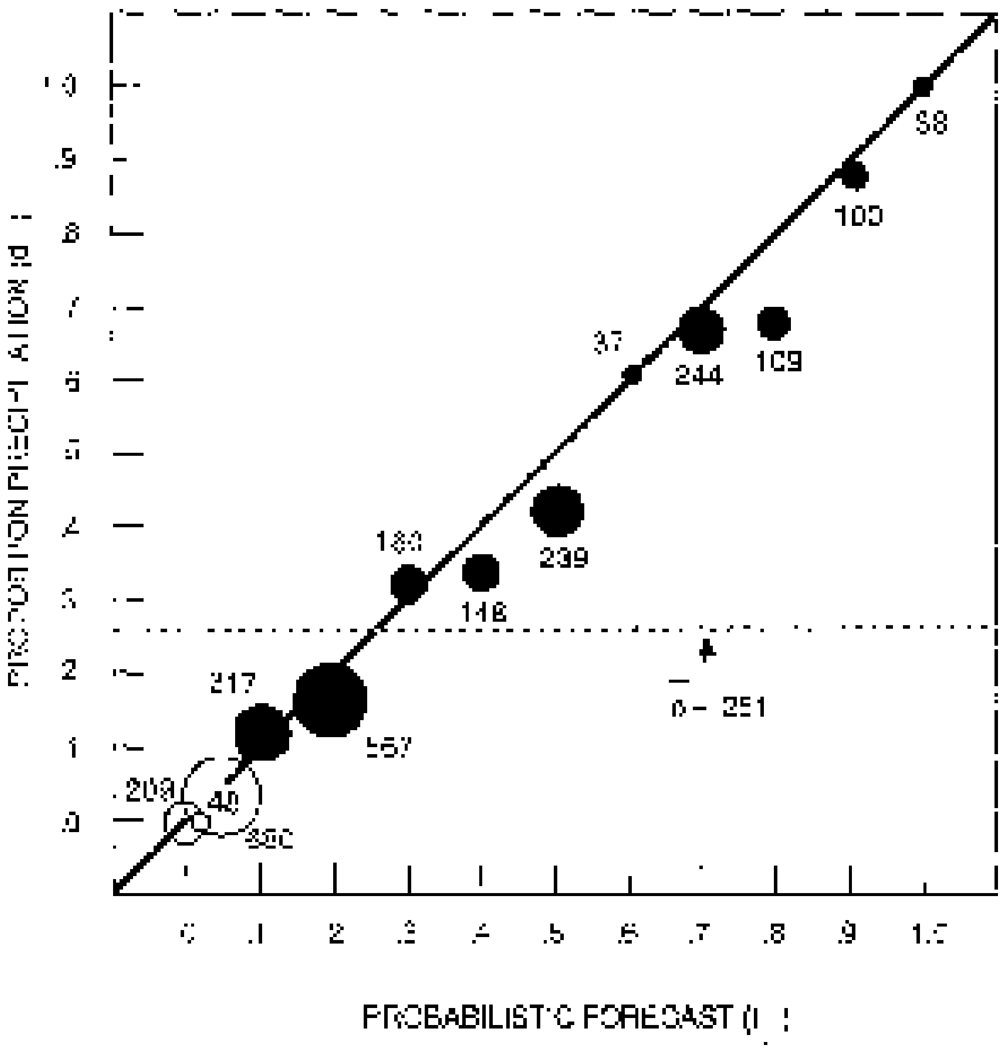
choose | indifferent | choose

Assessing Quality of Judgements

(Wallsten & Budescu, 1983)

- Reliability / stability
- Coherence / internal consistency (static and dynamic)
- External validity
- Converging validity (procedural invariance)
- Calibration

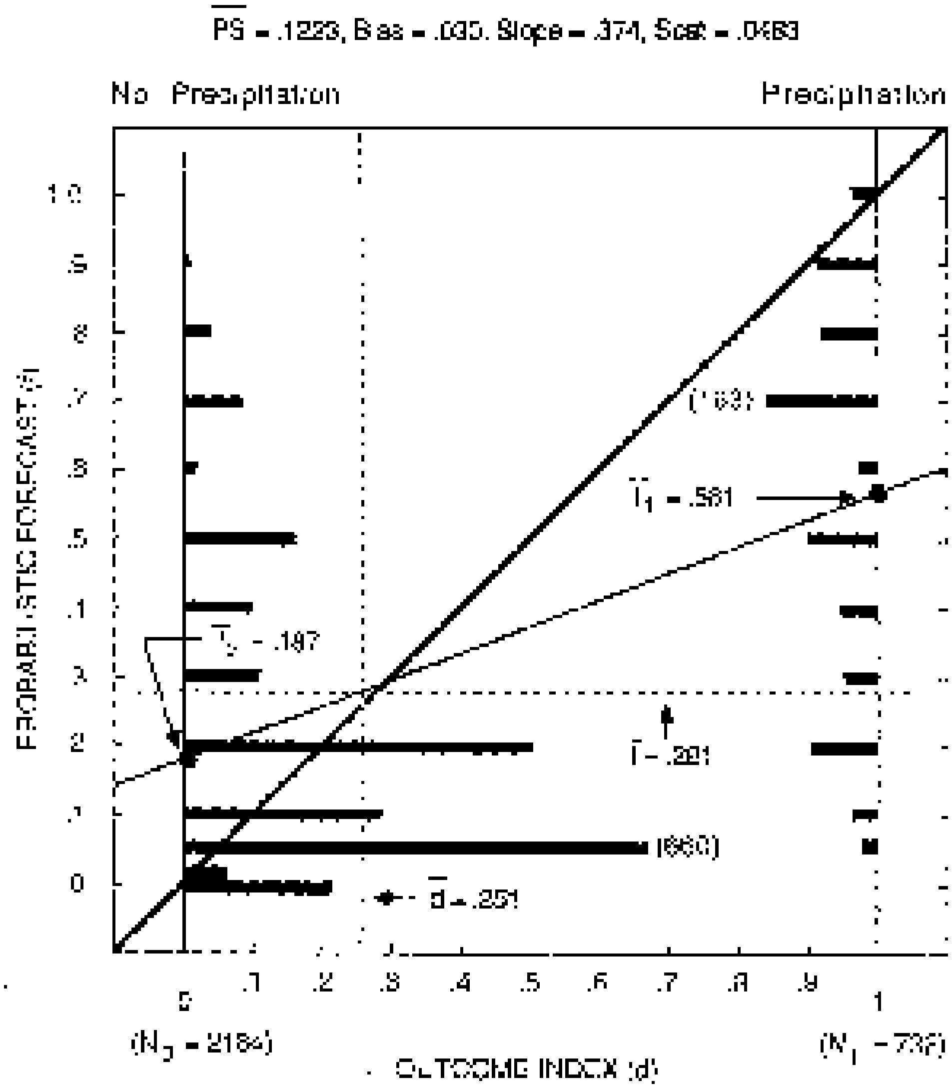
Calibration Curve



Measuring Calibration

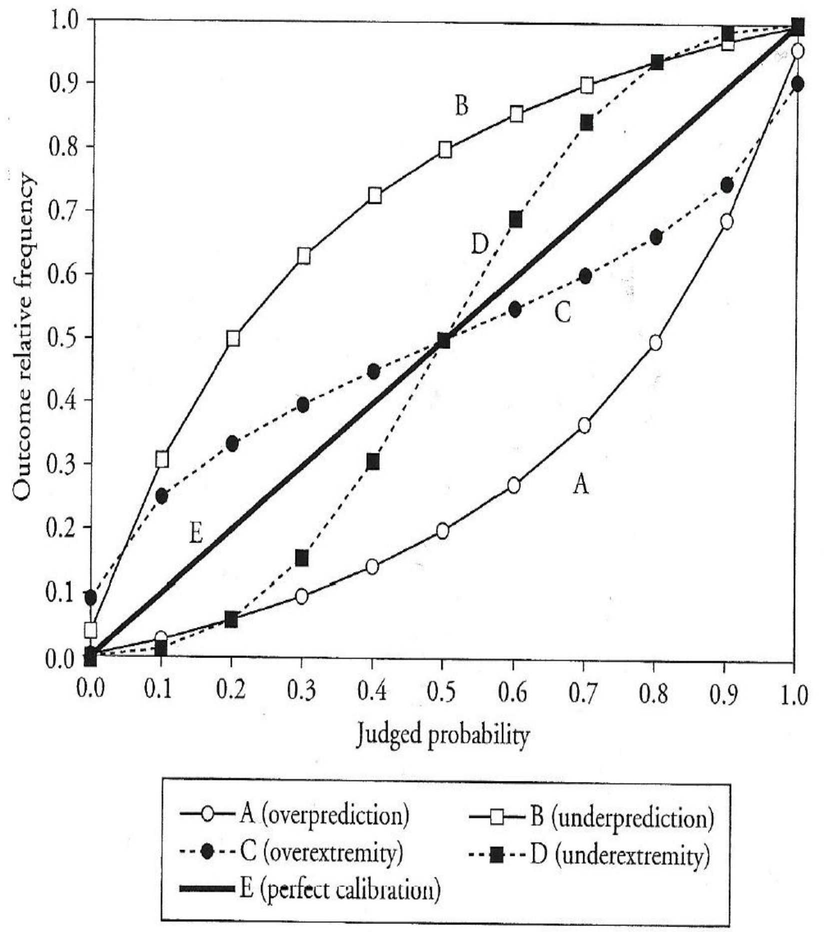
- Murphy (1972) decomposition of $S(P)$
  - For *designated* form: $S(P) = V - R' + C'$
    - Variance of outcome proportion
      $$V = \bar{x}\left(1-\bar{x}\right)$$
    - Resolution
      $$R' = \frac{1}{N}\sum_{j=1}^{J} N_j \left(\bar{x}_j - \bar{x}\right)^2$$
    - Calibration
      $$C' = \frac{1}{N}\sum_{j=1}^{J} N_j \left(p_j - \bar{x}_j\right)^2$$
    - All vary with designation (as does bias)
    - Brier Score :
      $$S(P) = \frac{1}{n}\sum_{i=1}^{n}\left(p_i - x_i\right)^2$$

Alternative View (Yates, 1990)



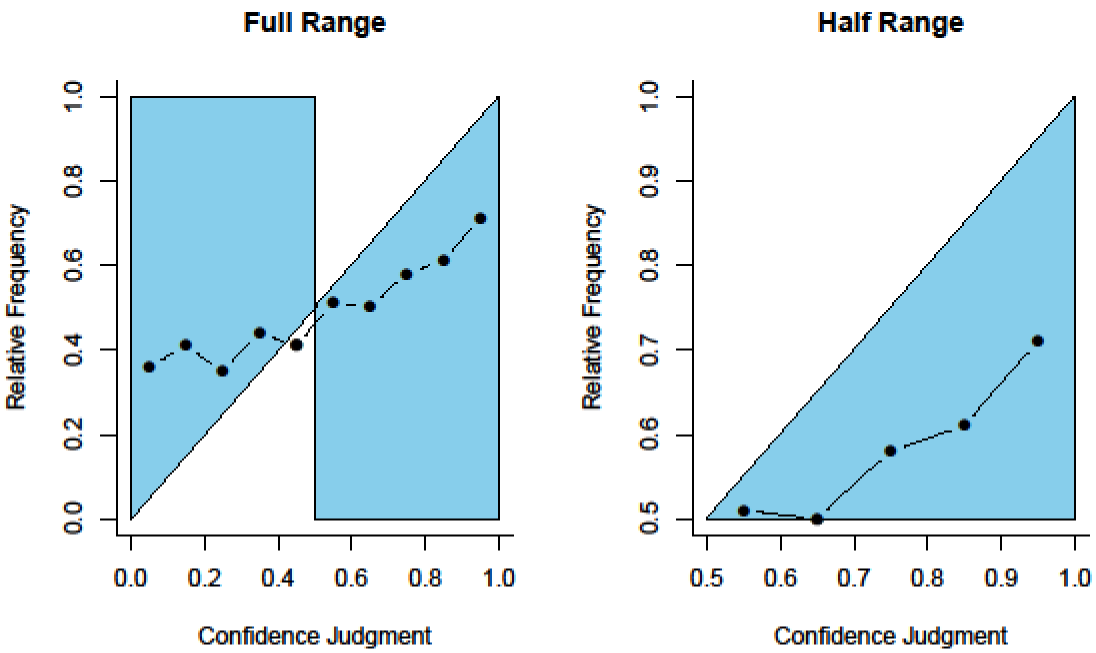
4.1.
d)

Patterns of Confidence

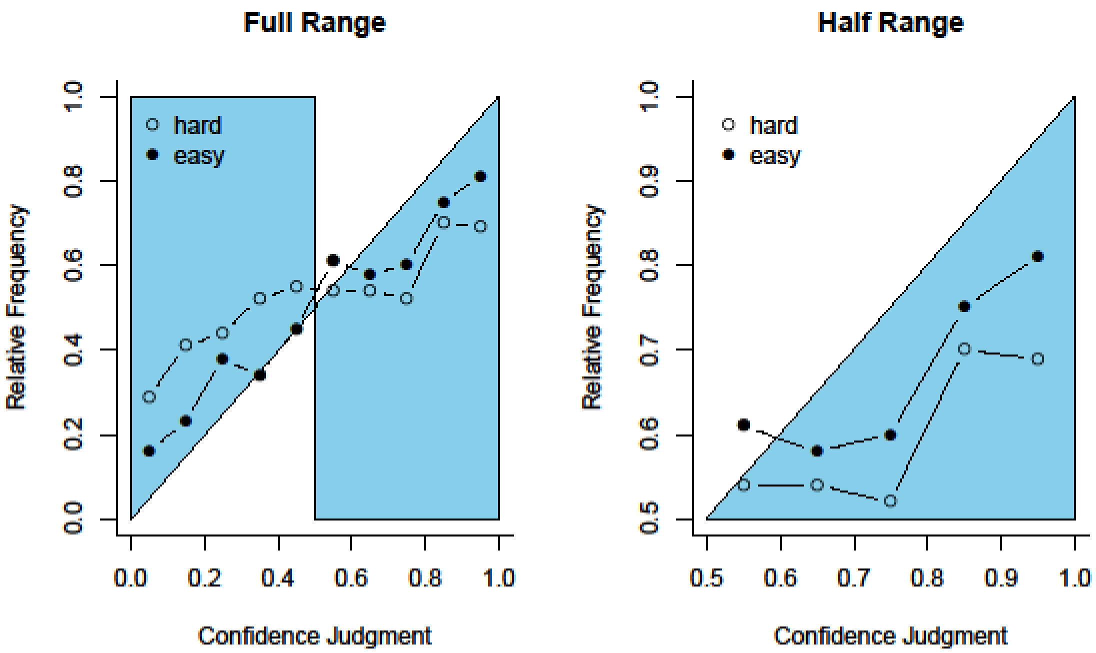


- Curve A: over-prediction
- Curve B: under-estimation
- Curve C: over-extremity
- Curve D: under-extremity
- Diagonal line E: perfect calibration

Empirical results – Over-extremity



Empirical Results: Hard Easy Effect



Possible Explanations

- Optimistic overconfidence
- Confirmation
- Ecological models
- Random errors with asymmetric distributions

Factors Affecting Judgments

- Cognitive (Heuristics)
  - Representativeness
  - Availability & Simulation
  - Anchoring & Adjustment
- Motivational
  - Desirability
  - Confirmation / Motivated Reasoning
  - Affect
- The structuring of the problem / task
  - Framing
  - Packing / Unpacking
  - Format / labeling / colors
  - Representation (probabilities vs frequencies)

Representativeness

- Judge likelihood of event, E, according to the degree that it resembles (it is perceived as representative of) a model or process, M
  - Base-rate frequencies/prior probabilities
  - Insensitivity to sample size
  - Misconception of chance
  - Conjunction fallacy
  - Insensitivity to predictability
  - Misconception of regression (toward the mean)

Availability & Simulation

- Judge likelihood of event, E, according to the ease with which it can be recalled, retrieved or imagined
  - Retrievability of instances
  - Effectiveness of a search set
  - Imaginability

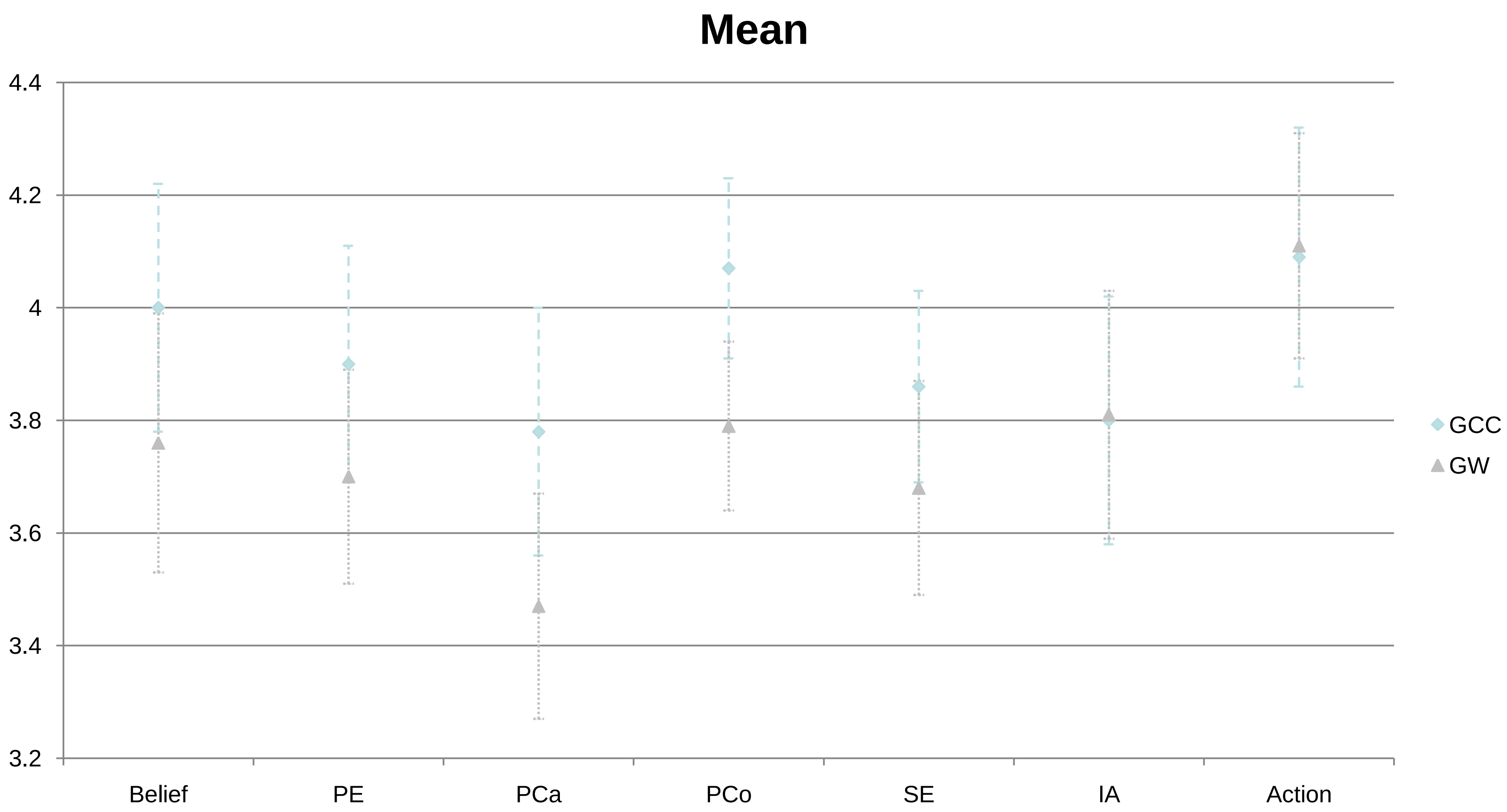
Both Representativeness and Availability can be explained by "attribute substitution" (Kahneman & Frederick, 2002)

Link to two systems

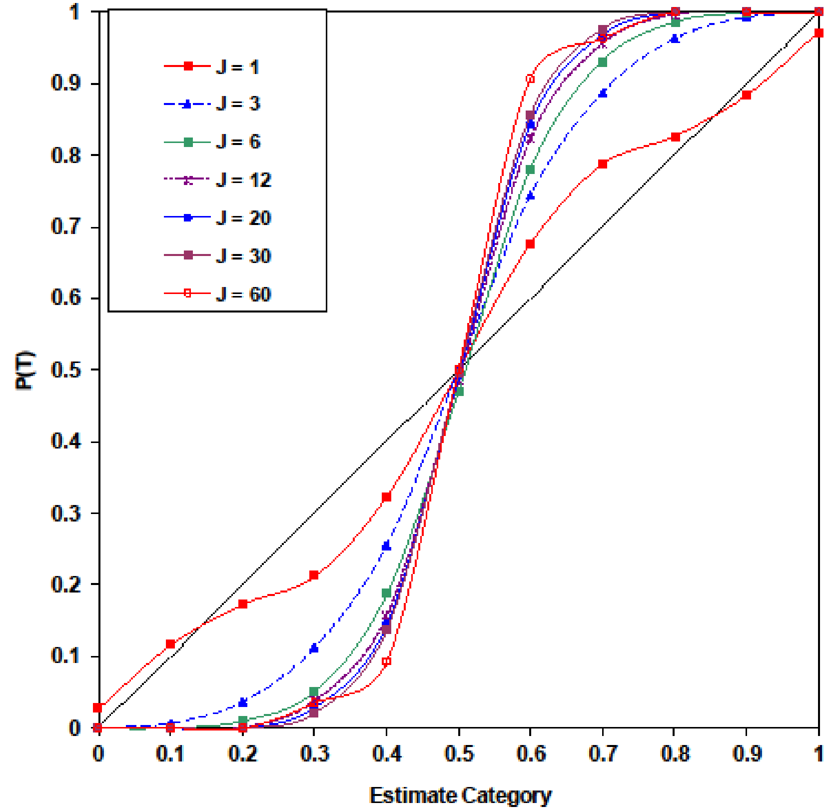
Affect

- The quality of ”goodness/ badness” that is experienced as a feeling state and marks the stimuli as positive/negative
  - Affect is attached to images that influence judgments
  - The evaluability of an attribute / dimension drives the precision of its affective feelings and increases its weight
  - Quantities evaluated may convey little meaning in the absence of appropriate context to induce the appropriate affective perspective
- *Examples:*
  - Gambles become more attractive when a small loss is added!
  - Common ratio effect (Imagining the numerator)

Labels (Global Warming / Climate Change)



Wisdom of the Crowds: Averaging Probability Judgments



Within-Item Crowd Size Analysis

- We analyze responses to 90 distinct items with at least 64 respondents
- For each item we construct “pseudo-crowds” with

  n = 1, 2, 4, 8, 16, 32, 64 respondents
- We average judges while keeping total amount of information constant:

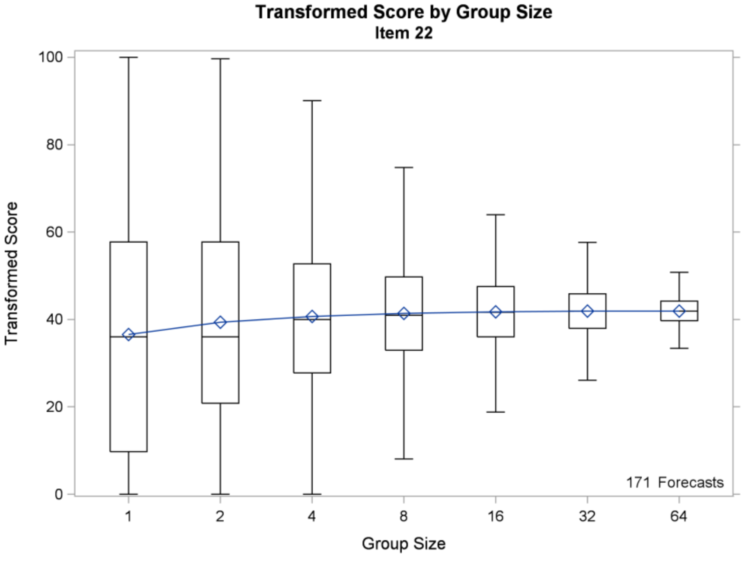
  n individuals, *n/2* dyads, *n/4* tetrads, *n*/8 octads, etc…
- We replicate the process 500 times
- Our score is a transformation of the Brier Score:

$$Score = 100 - 50[\sum_{Items} \sum_{outcomes} (group\ forecast - eventual\ outcome)^2]$$

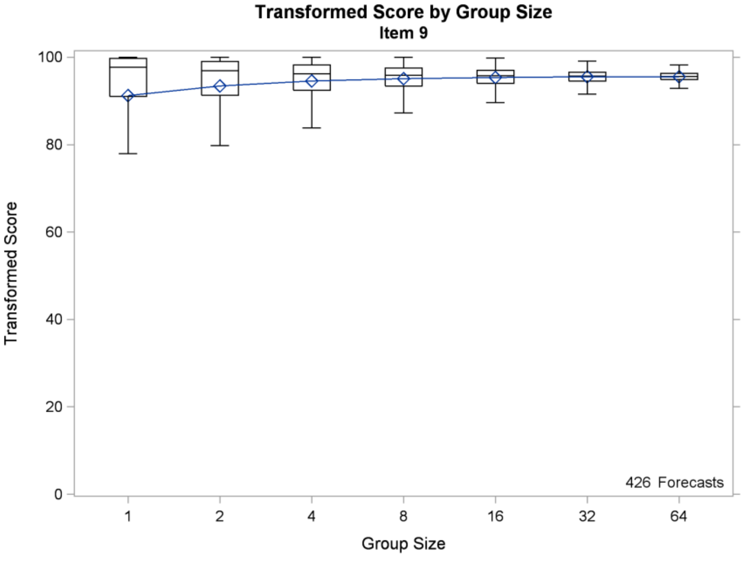
  – 100 = perfect, 0 = worst, 75 = “chance” (answer 50%)

Examples: Crowds Don't necessarily Improve Performance

Hard Item: Crowd does not improve much

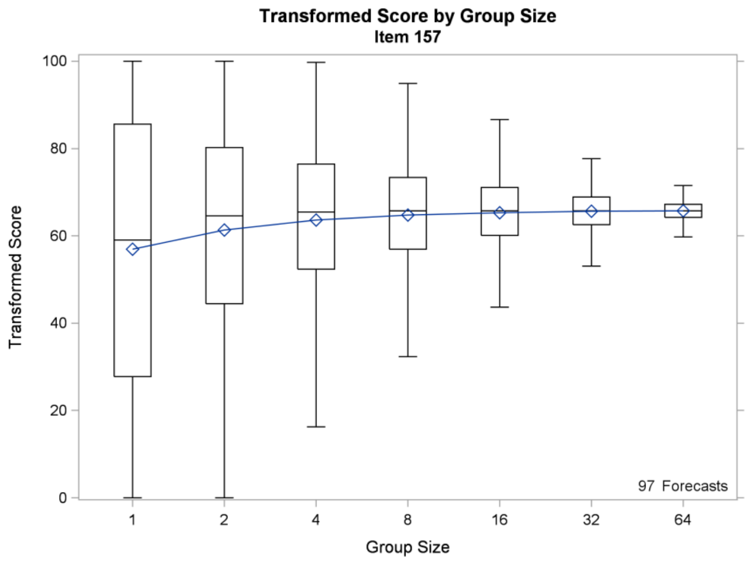


Easy Item: Crowd does not improve much

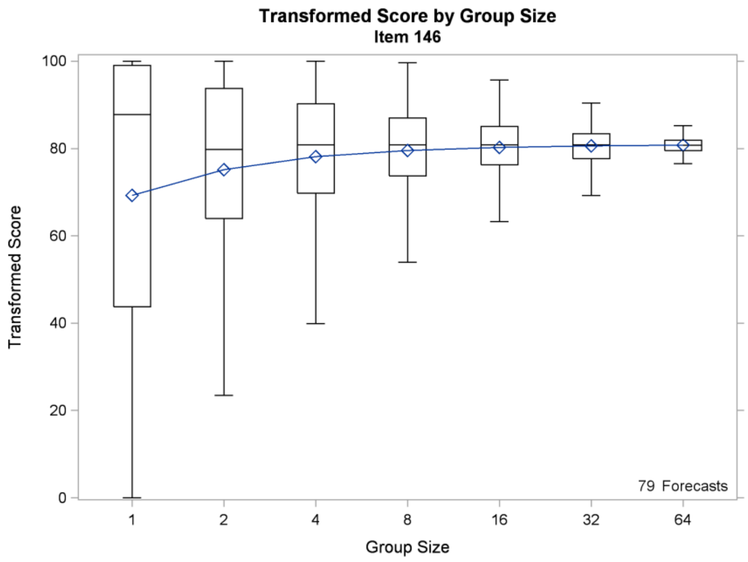


Examples: Performance Peaks at n=8

Slow Improvement



More Pronounced Improvement

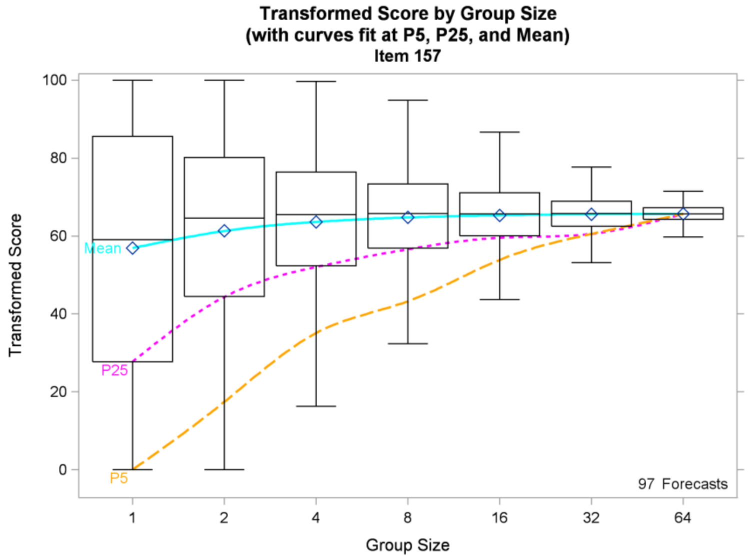


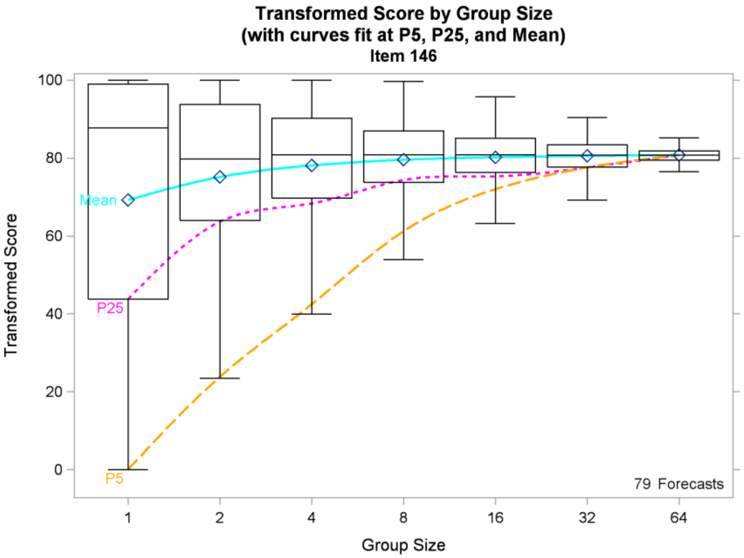
More on the Effects of the Crowd

- A more conservative approach focuses on other values of the distribution of forecasts (not the mean) in the distribution's lower tail
  - For example, one could model the values associated with the 25^{th} percentile (Q1) or the 5^{th} percentile of the distribution of forecasts
- Since the starting point of these statistics is much lower, the rate of growth as a function on n is steeper and more impressive

- The effects of aggregation peak later and require larger groups (For Q1, $n \approx 41$)

Examples Revisited





Judge – DM interaction and communication

Preferences

- In general, judges prefer to communicate uncertainty in vague terms but DMs prefer to receive precise information (Budescu & Wallsten, 1995; Brun & Teigen)
- This is also the modal individual pattern

The Congruence Hypothesis

- DMs are best served if uncertainty information is communicated in a way that matches the nature of the events and the underlying uncertainty.
- It makes no sense to use precise language to communicate vague uncertainty about ambiguous events (The chances of an *abrupt* drop in the market in the *near future* is <u>0.2348</u>)
- DMs are best served when the nature and language of communication match the type of uncertainty and context (Erev et al. 1991)
- DMs prefer communication modes that match the type of uncertainty (Olson & Budescu, 1997)

When (and Why) Do DMs Prefer Vague Information? (Du & Budescu, 2010)

- Earnings per share (EPS) forecasts issued by management of publically traded companies (33,625 quarterly forecasts by 4,744 companies issued between 1996 and 2006)

Range only – 36%; Point only – 22%

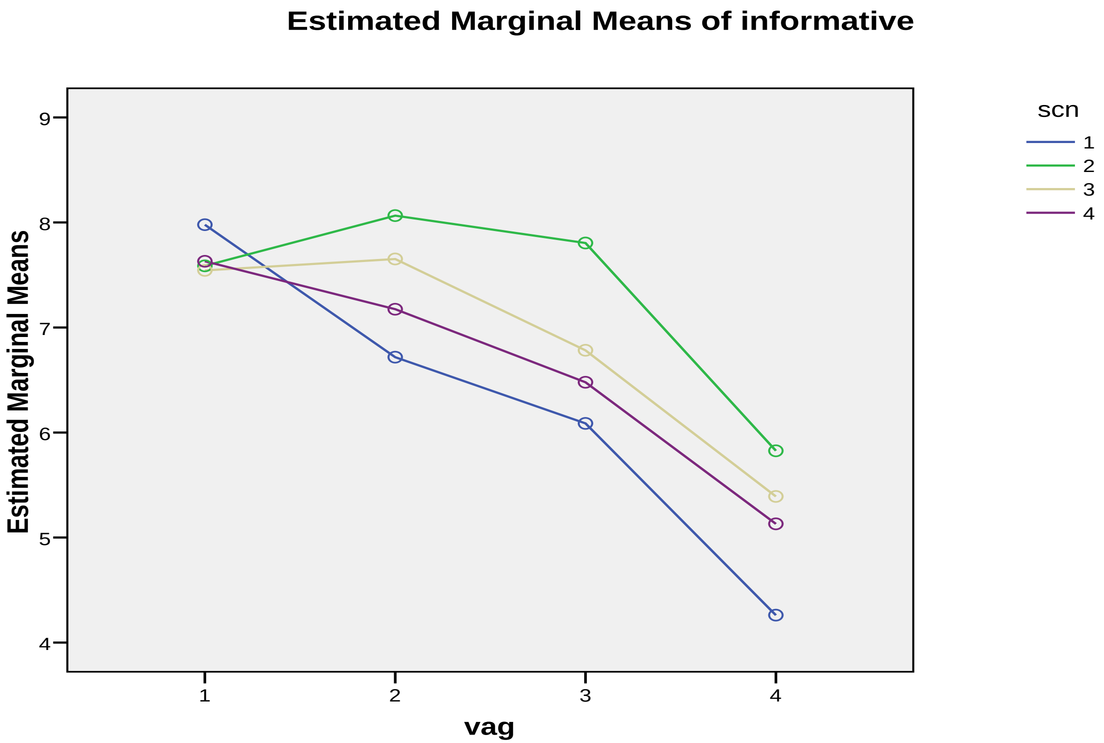
Mixed – 42% (Range / Points = 3 / 1)

Hypothesis – Management anticipates the investors' expectations and seeks to communicate to them information that is congruent with the level and nature of uncertainty underlying the forecasts

Experimental results

- DMs (MBA students) indicate preference to purchase companies that issue range forecasts
- This preference is more pronounced when the information underlying the forecasts is vague
- Non-monotonic pattern of attitude to imprecision – preference for moderate levels of vagueness (Yaniv & Foster)
- DMs (MBA students) judged range forecasts to be more informative, accurate and credible
- DMs *correctly* expect range forecasts to be more accurate (not because they are wider!)

Judged Informativeness In Various Domains



IPCC communication

IPCC Translation Table

IPCC Likelihood Scale	
Phrase	**Likelihood of Occurrence**
Virtually certain	> 99%
Very likely	> 90%
Likely	> 66%
About as likely as not	33% to 66%
Unlikely	< 33%
Very unlikely	< 10%
Exceptionally Unlikely	< 1%

Linguistic Probabilities

- Verbal lexicons of probabilistic terms vary widely across individuals
- Interpretations of probabilistic words are personal, subjective, susceptible to self-serving interpretations, and vary as a function of context
- It is difficult to “standardize” or “legislate” the meaning of language
- All these facts set the stage for a potential ”Illusion of Communication”

The Goals of the Studies

We investigate

- To what degree is the meaning of the IPCC probabilistic statements understood, as intended, by the public?
- Are there systematically biased misinterpretations?
- Are there simple ways of improving the efficiency of these communications?
- Do individual differences (gender, age, education, ideological, attitudes, etc.) affect systematically people's interpretations of these communications?

Budescu, Por & Broomell (2011)

- Extension of Budescu, Broomell & Por (2009)
- National (US) Sample:
  - Random sample representative of US population (n = 556, 41.% men; Age: mean = 48 SD=17).
- Task:
  - Read statements extracted from the IPCC summary reports containing 4 terms: *very likely*, *likely*, *unlikely*, and *very unlikely (*2 statements for each term).
  - Provide best estimate for each term.
- Attitudes toward Global Climate Change (*Belief in GCC*, *Personal Experience with GCC*, *Causes of GCC*, *Consequences of GCC*)
- Numeracy scores

- 3 Groups: Control, Translation, Verbal-Numerical (VN)

Reconstructions of climate data for the past 1,000 years also indicate that this warming was unusual and is ***unlikely*** to be entirely natural in origin.

On a scale from 0 to 100%, please indicate what is your best estimate of the probability conveyed by this statement.

0 25 50 75 100

Type in the number for the answer

30

Next

Example for Translation Group

It is ***very unlikely*** that climate changes of at least the seven centuries prior to 1950 were due to variability generated within the climate system alone.

On a scale from 0 to 100%, please indicate what is your best estimate of the probability conveyed by this statement.

0 25 50 75 100

Type in the number for the answer

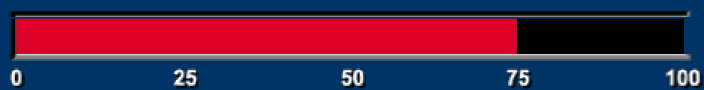
10

Phrase	*Likelihood of Occurrence/Outcome*
Virtually certain	> 99%
Very likely	> 90%
Likely	> 66%
About as likely as not	33% to 66%
Unlikely	< 33%
Very unlikely	< 10%
Exceptionally Unlikely	< 1%

Next

Temperatures of the most extreme hot nights, cold nights and cold days are ***likely (greater than 66%)*** to have increased due to anthropogenic forcing. [*Note: Anthropogenic forcing refers to the influences on the environment by human, rather than natural, factors.*].

On a scale from 0 to 100%, please indicate what is your best estimate of the probability conveyed by this statement.

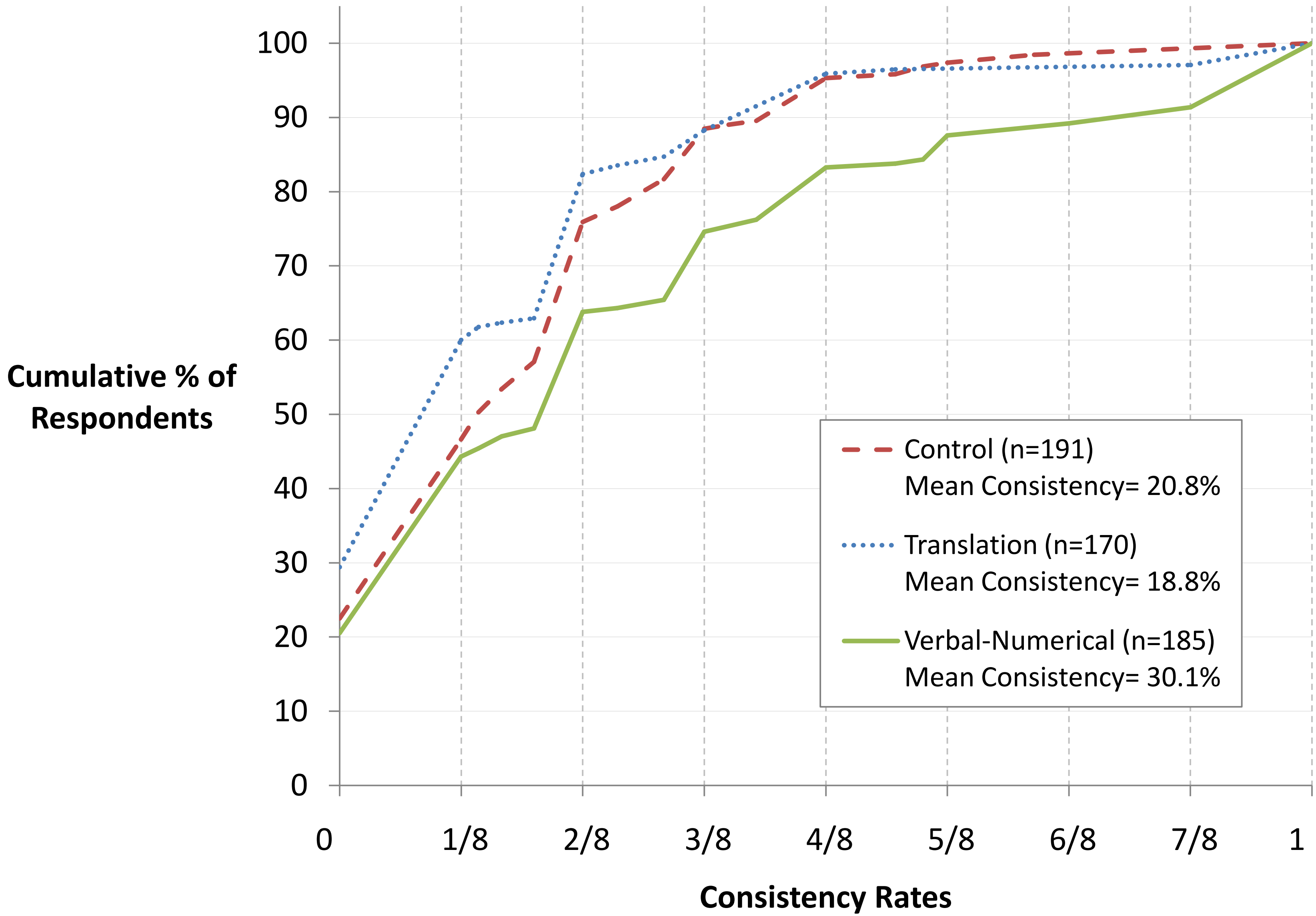


Type in the number for the answer

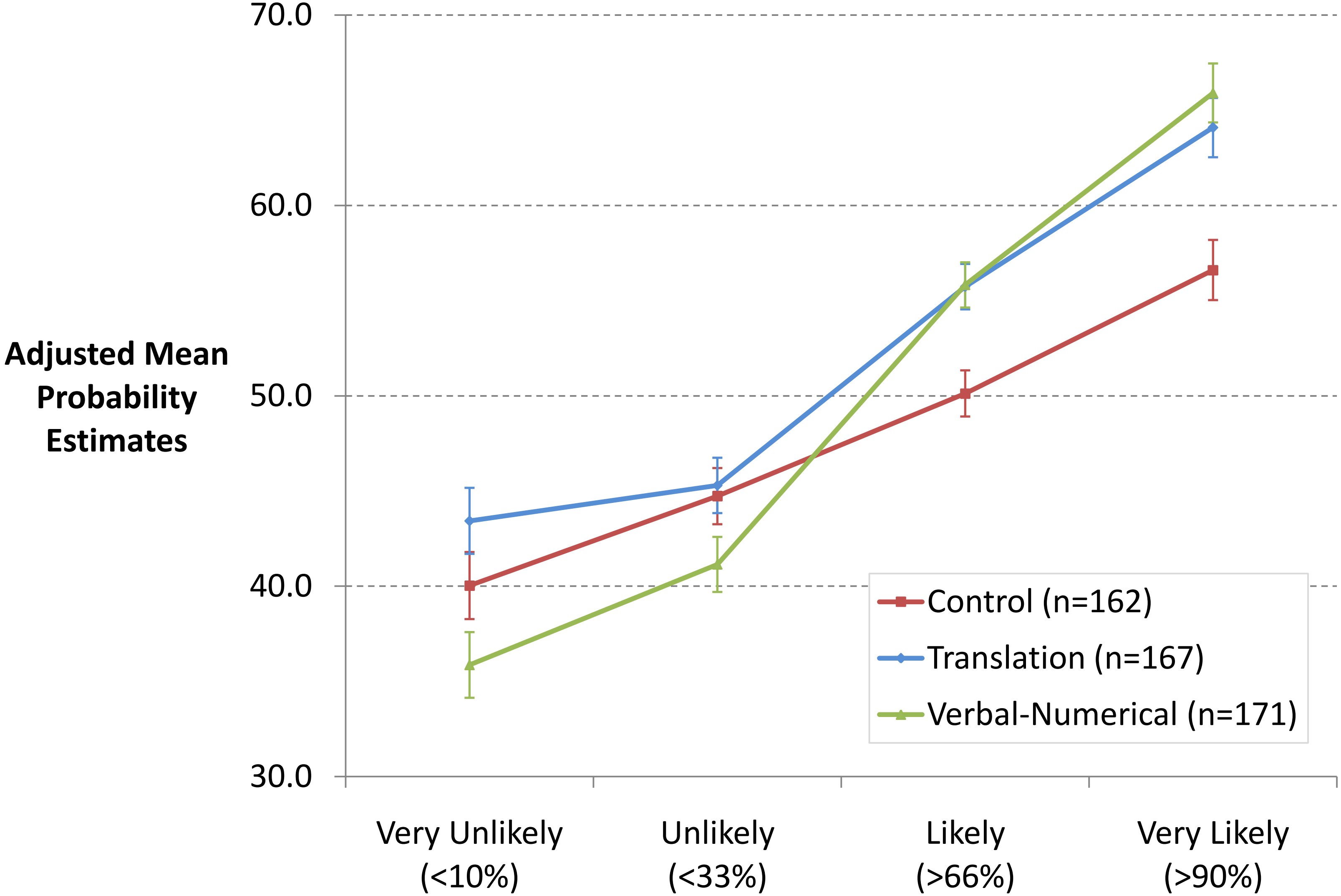
75

Next

Consistency Rates



Adjusted Mean Values (ANCOVA)



Correlation with Covariates

	Probability Estimates				Consistency Rate
	Very Likely	Likely	Unlikely	Very Unlikely	
BGCC	***0.56***	***0.52***	***0.29***	0.08	***0.15***
PE	***0.49***	***0.46***	***0.33***	***0.15***	0.04
PCa	***0.48***	***0.50***	***0.26***	0.01	***0.14***
PCo	***0.47***	***0.46***	***0.22***	-0.02	***0.14***
Numeracy Score	***0.17***	***0.16***	-0.04	***-0.15***	***0.14***

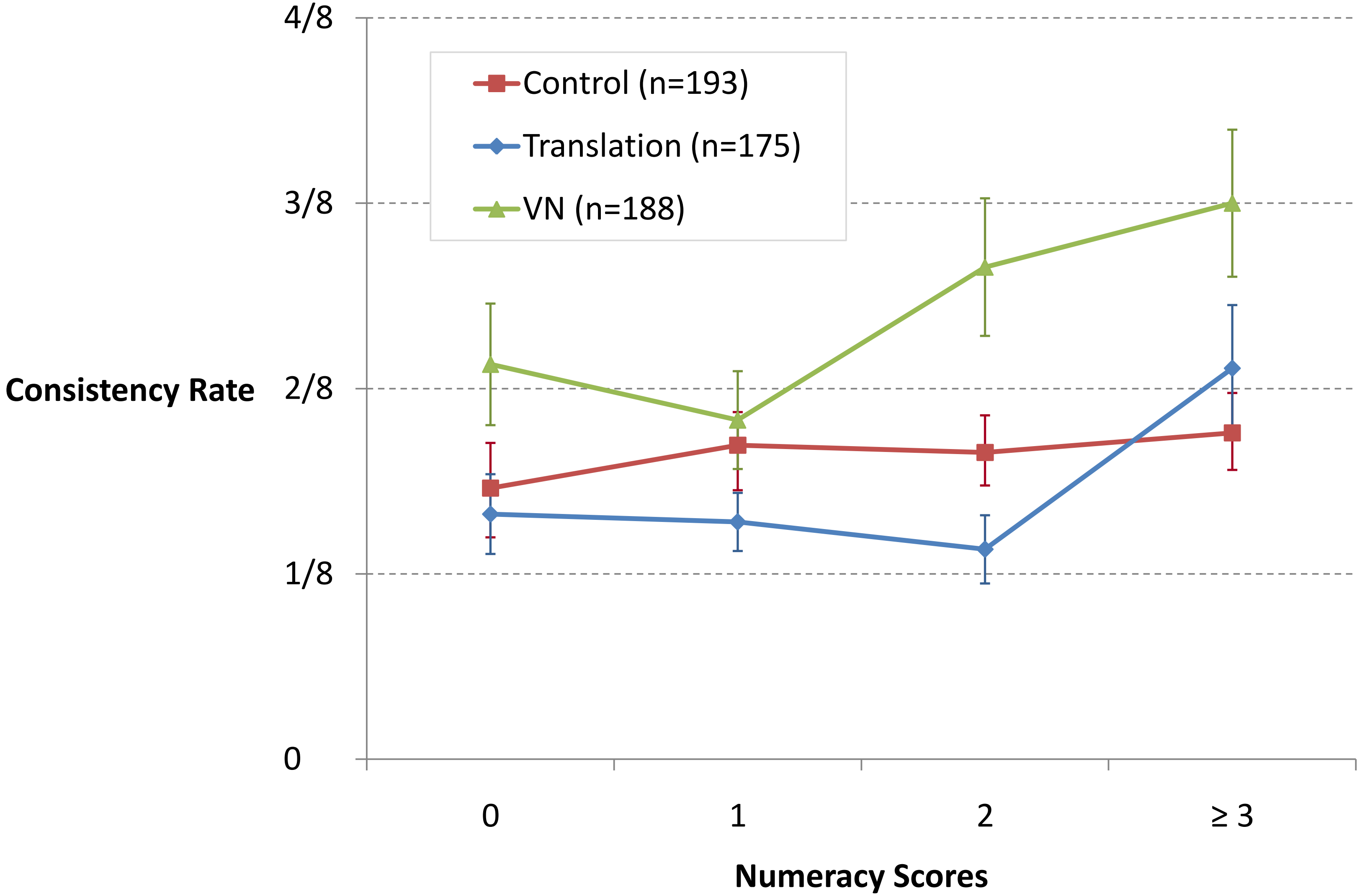
Note:
BGCC - Belief in Global Climate Change
PE - Personal Experience
PCA- Perception it is Caused by Human Activities
PCO- Perception of Consequences

Correlations in italicized bold are significant ($p < 0.05$).

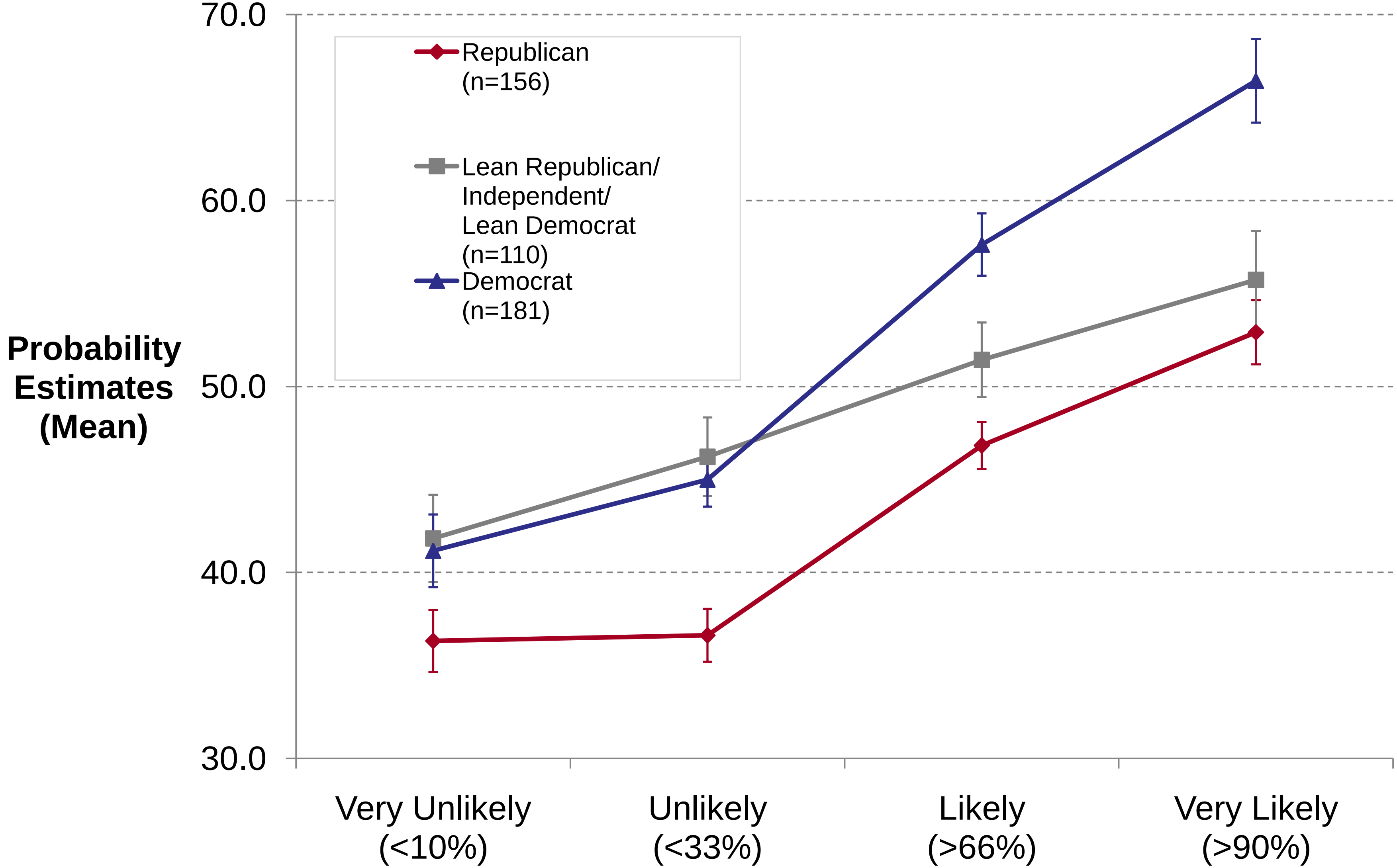
Numeracy Items

1. Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up as an even number? Answer: _______
2. In the BIG BUCKS LOTTERY, the chances of winning a $10.00 prize are 1%. What is your best guess about how many people would win a $10.00 prize if 1,000 people each buy a single ticket from BIG BUCKS? Answer: _______ people
3. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? Answer: ______ cents
4. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?   ____ minutes
5. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? Answer: ______ days

Relation to Numeracy



Relation to Political Affiliation



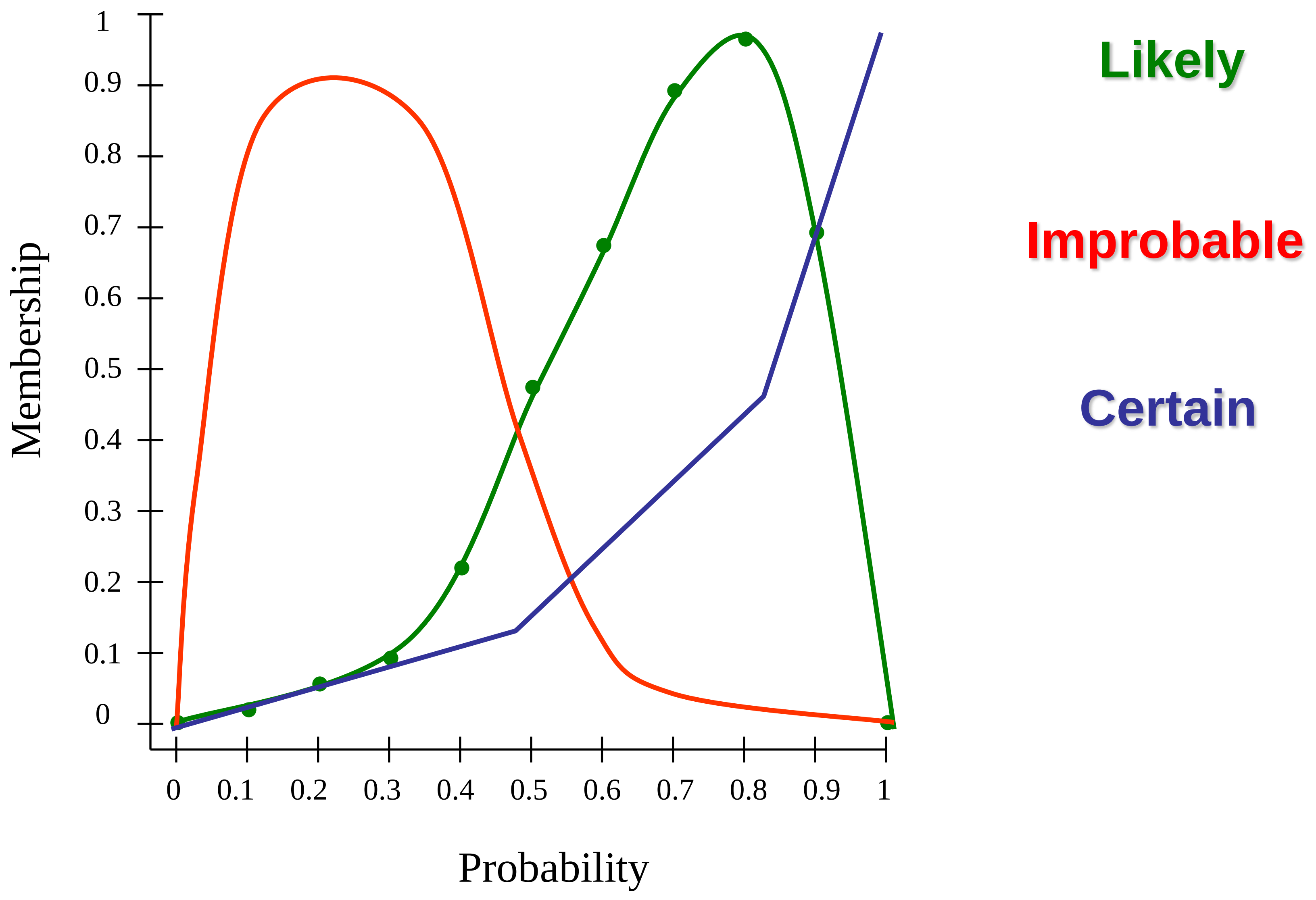
Summary And Conclusions

- The public consistently misinterprets the probabilistic statements in the IPCC report
- Less extreme than intended;
- High inter-individual variability;
- This variance is associated (to a large degree) with individual differences (mostly ideological)
- The dual (verbal – numerical) scale is superior to the current mode of communication as it
  - increases the level of differentiation between the various terms;
  - increases the level of consistency with the IPCC guidelines.
- Most importantly, these positive effects are independent of the respondents' ideological and environmental views.

Recommendations

- Avoid probabilistic pronouncements about ambiguous events and scenarios
- Continue use of several probability terms, but
- To improve quality of communication these words should be accompanied by *appropriate numerical ranges*
- Use different ranges to match the uncertainty of specific target events

Modeling Words with Membership Fs.



Decision making with imprecise numerical information (ranges)

The type of decision

Luce & Raiffa (1958) distinguish between decisions making under:

- *Certainty*
- *Risk*
- *Uncertainty (Ignorance)*

In reality these are just (easy to axiomatize and analyze) points along a continuum

Decisions under risk

The worth of a binary prospect *V(x,p;y,q)* is modeled as a bilinear combination of functions of the values, and the beliefs: $V(X,p;Y,q) = f(p)v(X) + f(q)v(Y)$

Beliefs	Outcomes			
	Values	Bernoulli Utility	VN-M Utility	Value Function
Probabilities	EV		EU	
Subjective Probabilities	SEV		SEU	
Decision weights				PT

Modeling ***Precise*** Prospects

- Prospect Theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992) distinguishes between the editing and evaluation of prospects
- The worth of a binary prospect $V(x,p;y,q)$ is modeled as a bilinear combination of its value function, $v(X)$, and the decision weights, $f(p)$:

$$V(X,p;Y,q) = f(p)v(X) + f(q)v(Y)$$

- The two functions have several distinctive properties

Modeling ***Precise*** Prospects

34 Daniel Kahneman and Amos Tversky

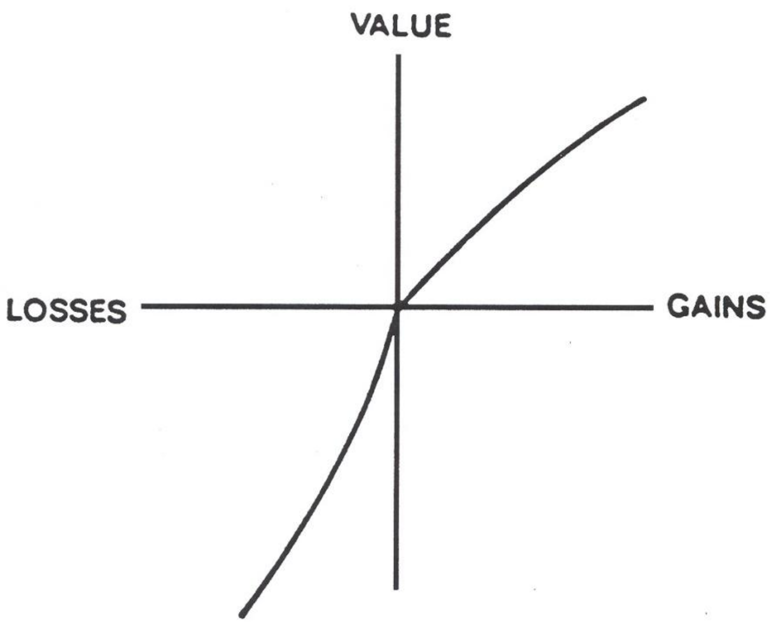
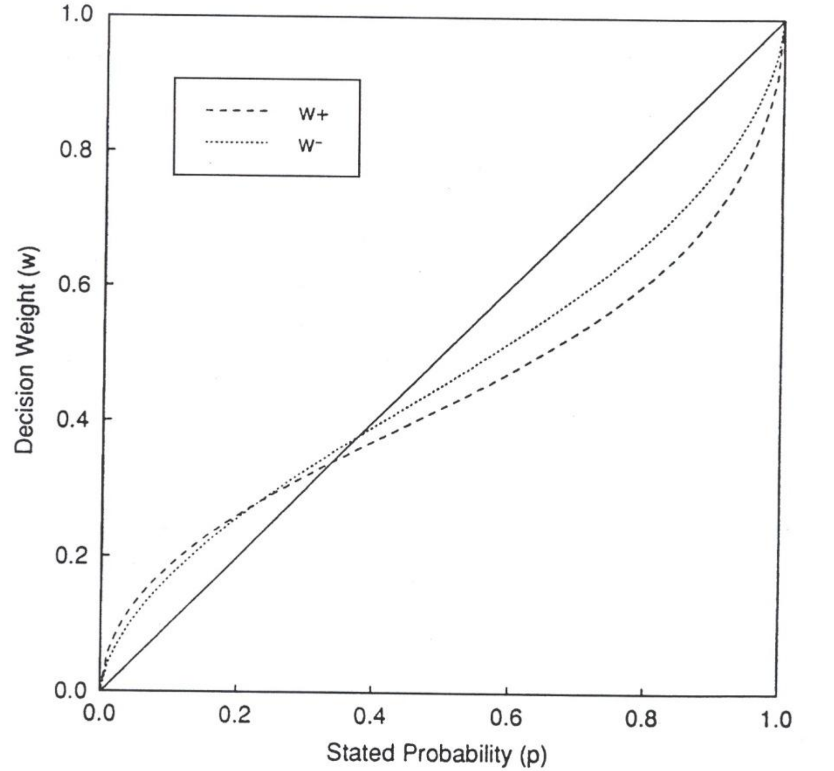


Figure 2.3. A hypothetical value function.

Figure 5.1. Weighting functions for gains ($w+$) and losses ($w-$)



Typical Instantiations of the Functions

$$v(x) = x^{\alpha} \; if \; x \geq 0$$

$$v(x) = -\lambda(-x)^{\beta} \; if \; x \leq 0$$

$$f(p) = \frac{p^{\gamma}}{[p^{\gamma} + (1-p)^{\gamma}]^{1/\gamma}}$$

The type of decision

Of particular interest is the “gray area” between *risk* and *ignorance* that includes many realistic cases, such as:

- Second order probability distributions
- Multiple priors (e.g., Ranking of states by their respective probabilities)
- Unreliable (imprecise) probabilities
- Upper Bound > Prob(Si) > Lower Bound
- Prob(Si) belongs to a fuzzy category (e.g. “likely”, “around, or in the, 80s”)

Decisions with Vague Probabilities

- Urn A: 50 Red and 50 Blue balls
- Urn B: ?? Red and (100-??) Blue balls
- Q1: If a Red ball is drawn you win $X. Do you prefer to draw from Urn A or B?
- Q2: If a Blue ball is drawn you win $X. Do you prefer to draw from Urn A or B?

- Ellsberg's paradox: In choices among a precise and an unspecified distribution people tend to prefer the precise option

Ellsberg's Paradox

Explanations of the prototypical pattern

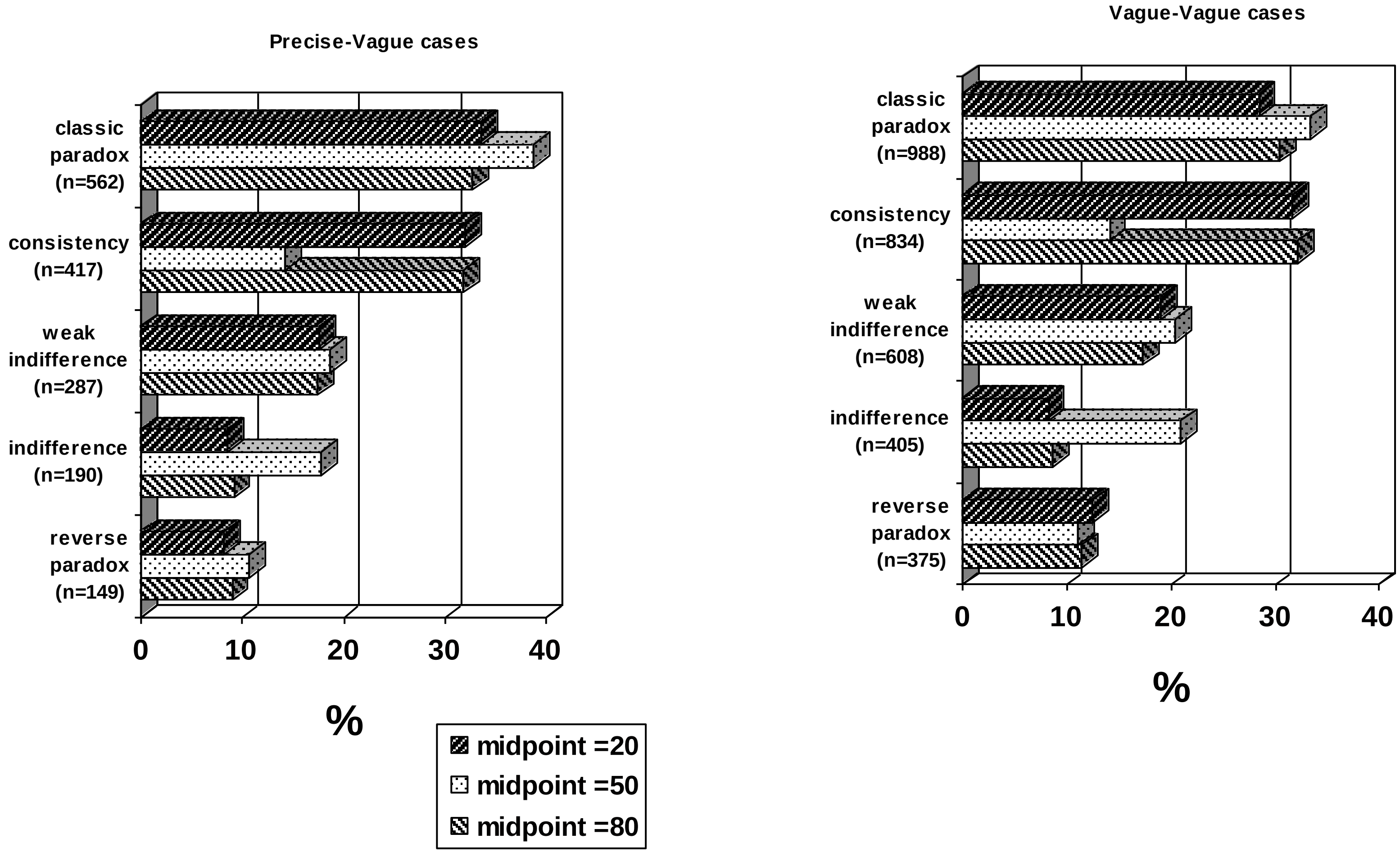
- Weighting by an "inferred/assumed" probability distribution (Ellsberg, 1961)
- Avoidance of vagueness (ambiguity) and preference for precision
- Competence (Heath & Tversky, 1991)

Ellsberg's Paradox

Explanations of the prototypical pattern

- Weighting by an "inferred/assumed" probability distribution (Ellsberg, 1961)
- Avoidance of vagueness (ambiguity) and preference for precision
- Competence (Heath & Tversky, 1991)

Ellsberg's Paradox (Kramer & Budescu 2004)

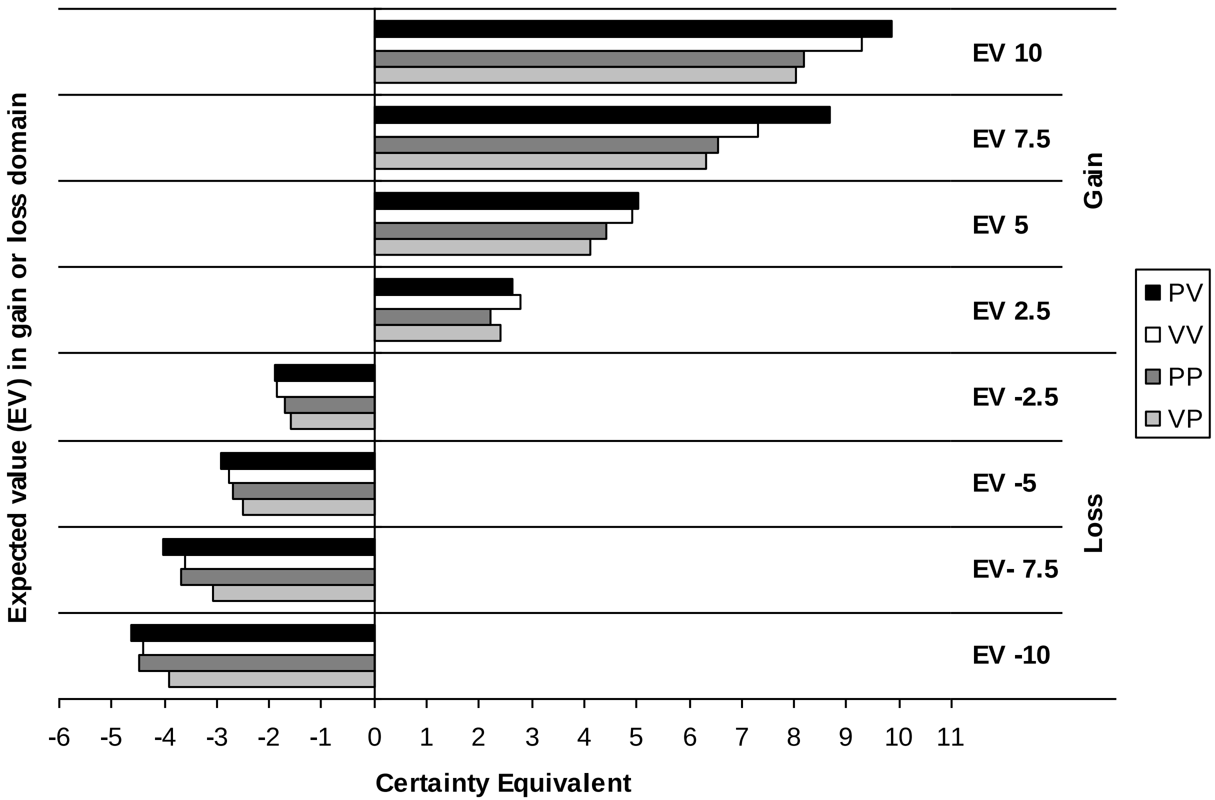


A common metric for vagueness

The prospects (p=0.05 to win ***between $45 and $105***), and (***p between 0.03 and 0.07*** to win $75) are equally vague since they span the same range of EVs (and identical midpoints).

Probs	Outcomes			
	$45	$75	$105	$45-$105
0.03				
0.05		$3.75		$2.25-$5.25
0.07				
0.03-0.07		$2.25-$5.25		

Certainty Equivalents of Prospects with Vague Parameters (Du & Budescu, 2005)



Summary of Attitudes to Various Sources of Vagueness (Du & Budecu 2005)

Task Used	**Type of Comparison**	**Domain**	
		Gain	**Loss**
CE	PP vs. PV	**V. Seeking**	No effect
CE	PP vs. VP	No effect	No effect
PC	PP vs. PV	**V. Avoidance**	No effect
PC	PP vs. VP	**V. Avoidance**	No effect
CE	PV vs. VP	**Outcome V. more salient**	No effect
PC	PV vs. VP	No effect	No effect

Modeling ***Vague*** Prospects

- In the editing phase, the DM "resolves the vagueness" of the range of probabilities or outcomes, so the decision problem is converted to one with "equivalent" precise parameters.
- This editing operation is performed by relying on the focal end-points of the interval
- The relevant range is replaced by a weighted average of its end points

$$v(Range\,X_l - X_u) = v(w_x X_l + (1 - w_x) X_u)$$

$$f(Range\,p_l - p_u) = f(w_p p_l + (1 - w_p) p_u)$$

Modeling ***Vague*** Prospects

- The coefficients *wx* and *wp* represent measures of attitude towards vagueness. For both:

w = 0.5 indifference to vagueness,

w > 0.5 vagueness aversion, and

w < 0.5 vagueness preference.

- The quantity |w – 0.5| measures *intensity of attitude towards vagueness*
- Comparison of |wp - 0.5| and |wx - 0.5| contrasts the *relative sensitivity to the sources of vagueness*

Decisions with Vague Probabilities with Decision Aids (Budescu et al. 2009)

- Instead of focusing on the contrast between vagueness and precision we examine how choice between various actions is affected by the level of imprecision
- The decision problem is designed to mimic some climate change problems
- We also study the effect of two classes of decision aids

The Decision Problem

- DM is endowed with \$e, and faces an urn that contains 100 Red and White balls

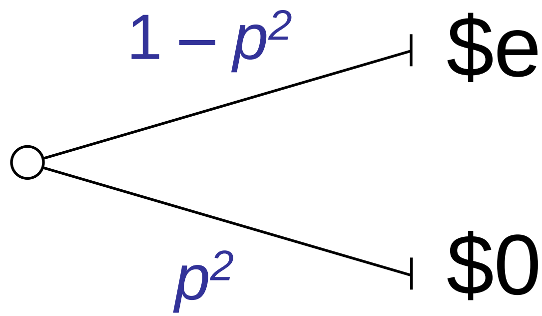
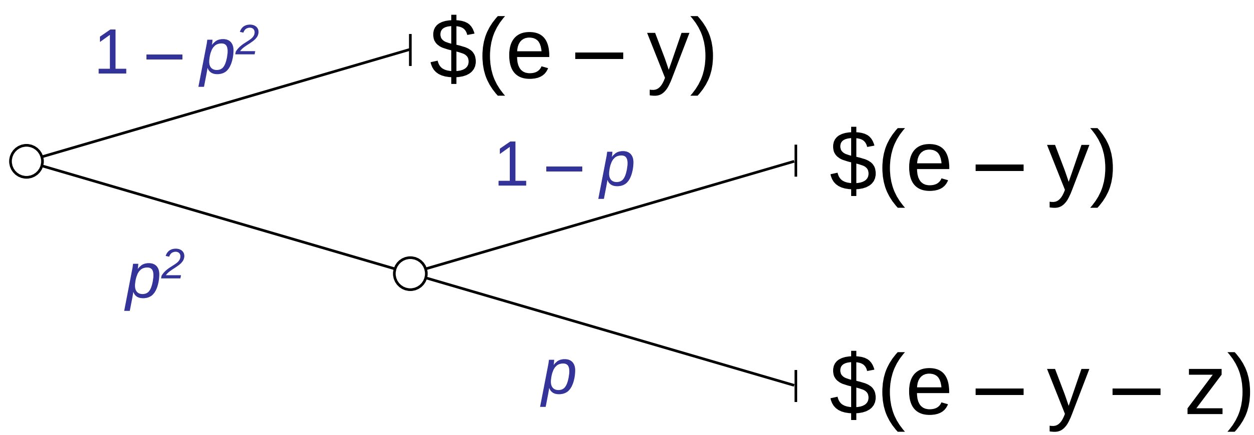
$Pl \leq P(Red) \leq Ph.$

The Decision Problem

Choose one of 3 actions:

- Risky: Two balls are sampled. If both are Red, DM loses the endowment
- Riskless: Surrender a portion of the endowment, $f
- Reduced Risk: Pay fee ($y); draw 2 balls; if both are Red, draw a 3rd. If it is also Red pay another $z.

The Decision Problem

<table>
<tr><td>Risky</td><td>
</td></tr>
<tr><td>Riskless</td><td>$(e – f)</td></tr>
<tr><td>Reduced Risk</td><td>
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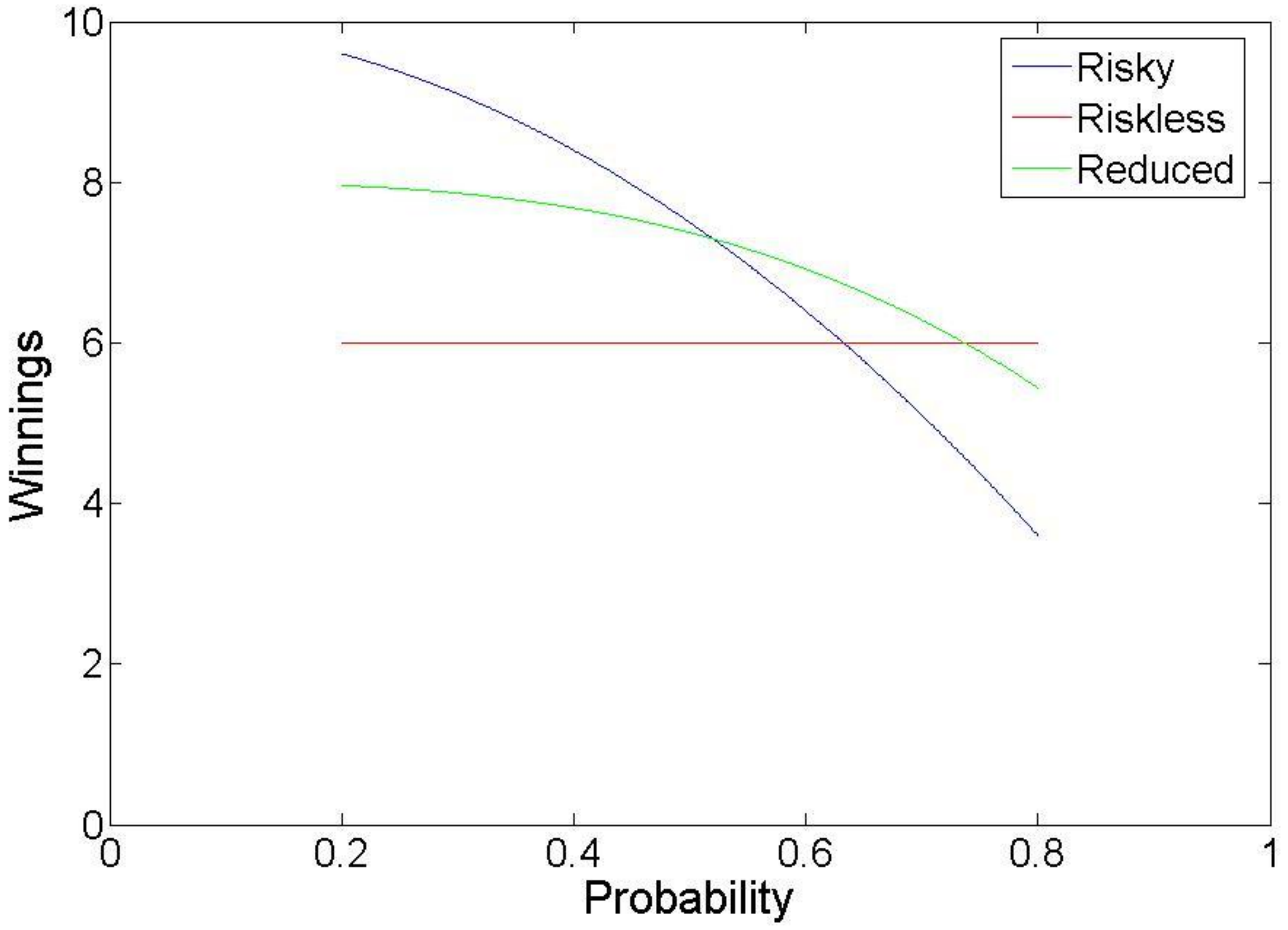
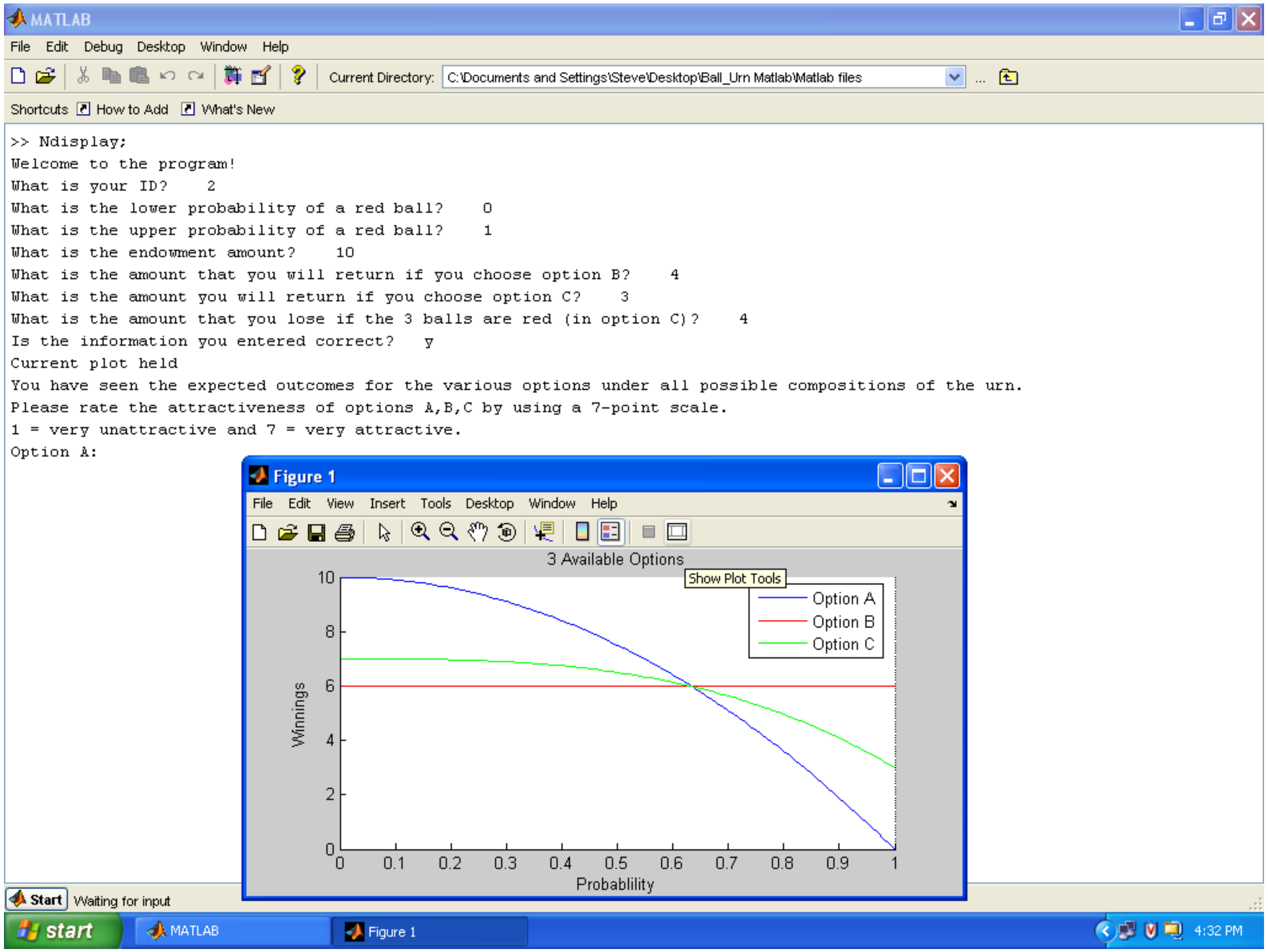
Relating the Decision Problem to Abrupt Climate Change

- ***Risky*** Option represents continued emissions (BAU).
- ***Riskless*** Option represents capping of greenhouse gas emissions at very low levels immediately
- ***Reduced Risk*** Option represents less costly options that reduce some (but not all) the risks

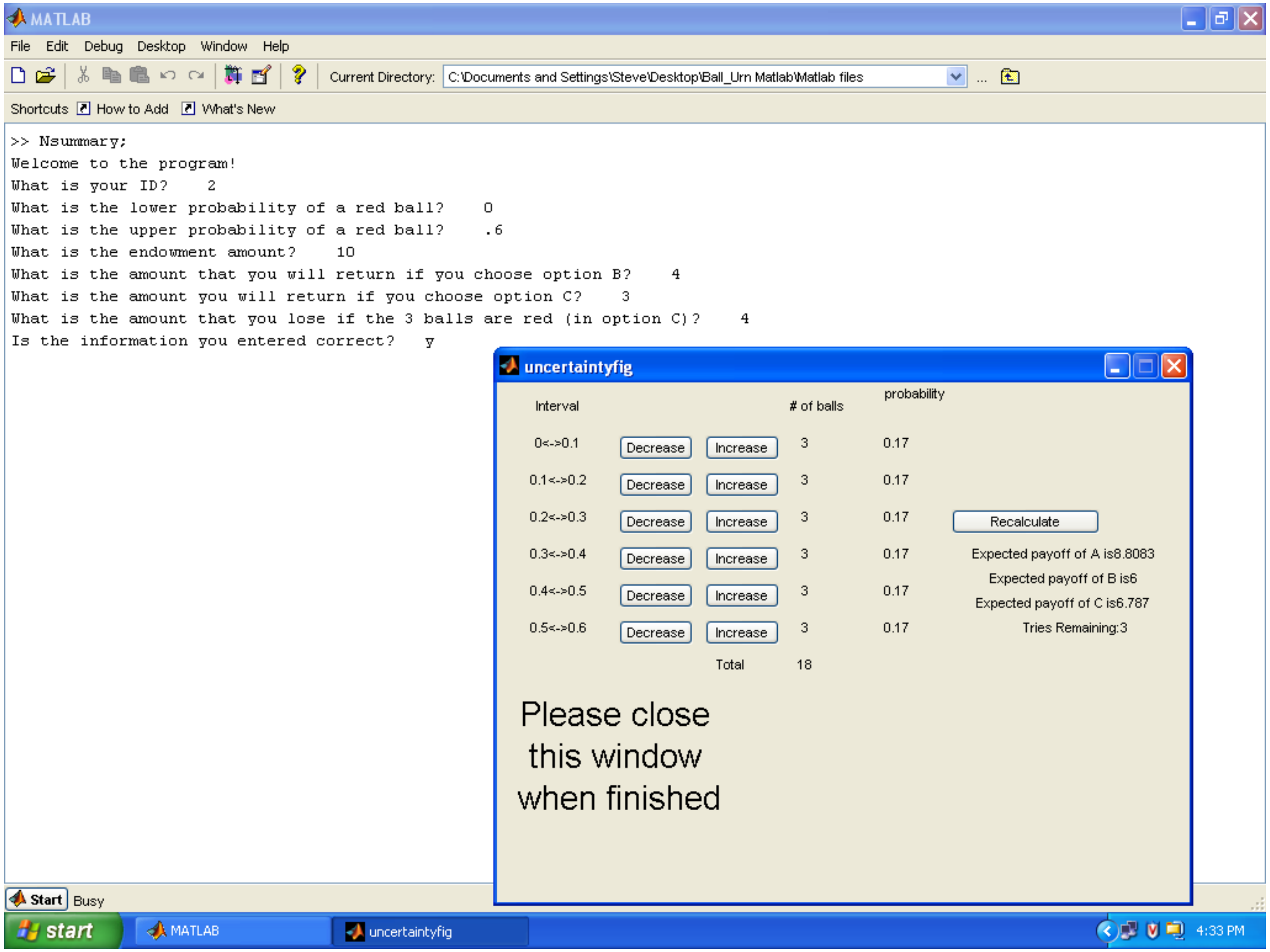
Example of Decision Problem: $0.2 \leq p \leq 0.8$, e=\$10, f=\$4, y=\$2 , z=\$5



Experimental Details: Display



Experimental Details: Calculator



Attractiveness of the Actions as a Function on Vagueness

As vagueness increases, the Riskless (most conservative) action becomes more attractive at the expense of the Risky action

Vagueness	Risky	Riskless	Reduced Risk
0.40	41	26	33
0.60	37	29	34
0.80	39	36	34
1.00	30	38	33

Attractiveness of Actions as a Function of the Decision Aid

The availability of decision aids (especially the EV calculator) make the ***Risky*** Option more attractive, at the expense of the ***Riskless*** one.

Condition	Risky	Riskless	Reduced Risk
Control	37%	34%	29%
Display	43%	27%	30%
Summary	50%	22%	28%

Modal Choice as a Function of Range and Midrange

High and vague probabilities cause subjects to prefer the riskless action, while low and less vague probabilities cause subjects to prefer the risky action

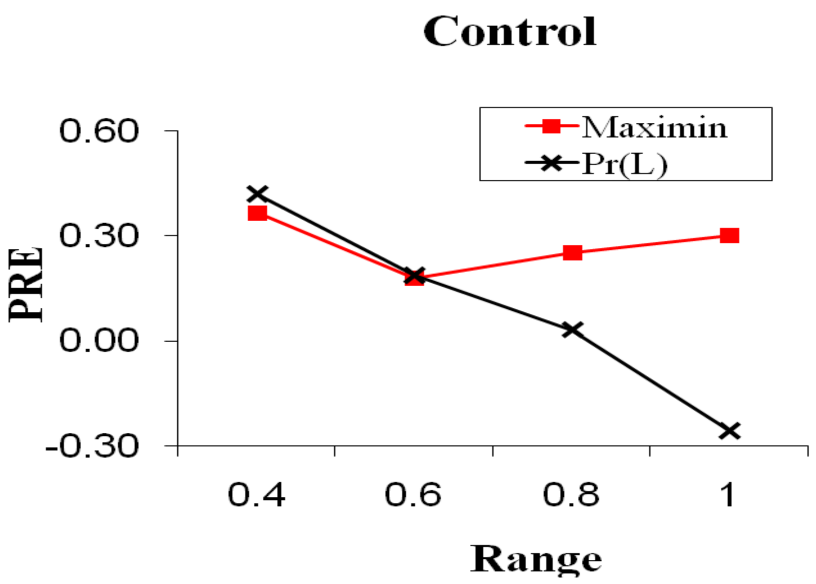
	Range			
Midrange	0.4	0.6	0.8	1.0
0.3	Risky	Risky		
0.4	Risky	Risky	Risky	
0.5		Riskless	Riskless	Riskless
0.6			Riskless	

Decision Models Being Compared

Class	Model	Model	Key Index	Choice Criterion
1	1	Maxi-min	Lowest outcome for each action	Maximal
	2	Maxi-max	Highest outcome for each action	Maximal
2	3	Mini-max Regret	Highest regret for each action	Minimal
	4	Mini-min Regret	Lowest regret for each action	Minimal
3	5	$P^{(U)} = P_U/(1 + P_U - P_L)$	Proportional to the upper bound	Maximize EV
	6	$P^{(L)} = P_L / (1 + P_L - P_U)$	Proportion to the lower bound	Maximize EV
	7	$P^{(M)} = (P_U + P_L)/2$	Mid-range	Maximize EV
4	8	Laplace	Expected value for each action	Highest EV
	9	Starr	Expected value for each action	Highest EV for most probabilities

Models That Describe Best the DMs' Choices

As the vagueness increases DM's choices are better predicted by a conservative (ignorance based) MaxiMin model



Social Dilemmas
With Uncertain Resources

The setup

- Social dilemma in group with N participants which can cooperate (C) or defect (D):
  - V(D) > V(C)   each person prefers D
  - All(C) > All (D)   the collective benefits from C
- Examples:
  - Common Pool Resource
  - Provision of Public Goods
- *Uncertainty* about the size of the pool or the size of the PG

- Experiments on CPR with random resources (Rapoport, Suleiman & Budescu)

Mean Individual Requests (N=5, E(Pool size) = 500

Range	Sample size	Mean	SD
0	167	106	55
5	120	113	75
70	60	115	78
200	120	122	85
250	55	125	96
380	60	110	72
500	80	122	103
560	120	137	109
750	55	135	112
1000	90	162	130

Provision of Requests

Range	Group Size		
	2	3	5
0	96	64	47
100	29	29	11

Summary

- Behavioral research on judgment and decision making under conditions of vagueness / ambiguity can provide numerous important insights and sometimes subtle and surprising insights
- Some of the accepted “common wisdom” about the impacts of imprecision hat permeate the literature may be over- generalizations.

Summary

How to communicate uncertainty?

- Scientific evidence should be presented at the highest level of precision warranted by the available data (but not more precisely)
- DMs are best served if uncertainty is communicated in a way that matches the nature of the events and the underlying uncertainty.
- Uncertainty communication should be associated with unambiguous events / statements
- Relatively small changes in presentation format may have considerable effects of the quality of the message

Caveats

The results of these experiments are

- Based primarily on samples of students
- Involve small monetary amounts
- Do not involve extreme probabilities
- Detached from organizational / ideological / political contexts