

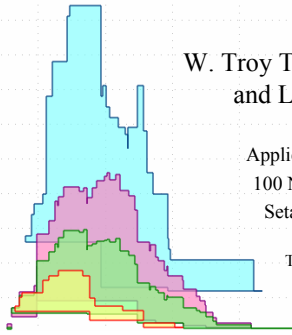
Risk perception and the problems we make for ourselves

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Presented March 3, 2005 to the
SRA, Northeast Chapter



Why is risk communication hard?

Public risk perception is often termed “irrational”

But maybe what experts have been telling people is incomprehensible or incomplete

How are people *evolved* to comprehend risk?

What leads to variation in risk perception?

An emerging view of mind (evolutionary psychology)

Mind consists of many domain-specific calculators

(Marr 1982; Barkow et al. 1992; Pinker 1997, 2002)

Information *format* triggers a specific calculator

(e.g. Cosmides & Tooby 1996; Gigerenzer 1991)

Emotions provide prior probabilities to calculations

Multiple calculators produce contrasting solutions

Emotions also choose among and combine solutions

(e.g. Glimcher & Rustichini 2004 and references therein)

List of mental calculators (after Pinker 2002)

- Language (grammar and memorized dictionary)
- Practical physics (pre-Newtonian)
- Intuitive biology (animate differs from inanimate)
- Intuitive engineering (tools designed for a purpose)
- **Intuitive psychology (deception, mistrust)**
- Spatial sense (dead reckoner and mental maps)
- **Number sense (1, 2, 3, many)**
- **Probability sense (frequentist Bayes)**
- **Practical economics (reciprocity, trust, equity, fairness)**
- Mental database/logic (logical/causal operators link assertions)

People are *good* risk assessors

When provided with natural frequencies

76-92% correct Bayesian reasoning

(Cosmides & Tooby 1996; Gigerenzer 1991)

When faced with short-term variability

Foraging, maximizing rewards or minimizing costs

(Hawkes et al. 1982; Bechara et al. 1997)

When engaged with multiple actors

Cheater detection, ultimatum game

(e.g. Cosmides 1989; Guth 1995)

People are *bad* risk assessors

... or often *seem* bad when

1. **Risk is seen to be imposed**
2. **Experts tell them the risk**
3. **Presented with incertitude (versus variability)**
4. Presented with percentages, large numbers, or single-event probabilities
5. Encountering probabilistic independence
6. Prior probabilities are remembered or imagined

1. When risk is imposed

More risk is perceived

Even when the risk is smaller than voluntary risks

Multiple mental risk calculators perceive risk

Some perceive risk of disease, death, economic cost

Some perceive risk of social contract violation

(e.g. Cosmides 1989, Guth 1995)

Bilateral anterior insula: disgust (e.g. Sanfey et al. 2003)

2. When experts tell the risk

Trust in ability depends upon uncertainty

Consensus vs. inclusion

(ventromedial prefrontal cortex)

Trust in motive depends upon shared goals

(Earle 2004)

(ventromedial prefrontal cortex, anterior cingulate cortex, dorsolateral prefrontal cortex: Freedman et al. 2004)

Precautionary principle

3. When risk is uncertain

Uncertainty triggers a specific calculator(s)

ventromedial prefrontal cortex

(Glimcher & Rustichini 2004; O'Doherty et al. 2001; c.f. Loewenstein et al. 2003)

Evolution favors caution in the face of ambiguity

Death is an absorbing state

Lay public concentrates on the worst case

But ignores how unlikely the bad outcome is

Precautionary principle

Imaging perceived risk

Use uncertainty bounding to image risk

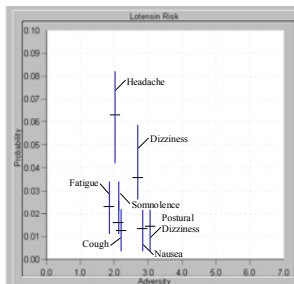
– Based upon f/N curves (Farmer curves) and tolerability of risk concepts

See risk as perceived by different stakeholders

– Industry, FDA approval, FDA post-marketing, consumer groups

Quantifying uncertain frequency

Frequency: Confidence intervals, Wally previsions



Quantifying uncertain adversity

Adversity: how bad is it if x occurs?

Many scales possible

Mortality rate, expected years of life lost

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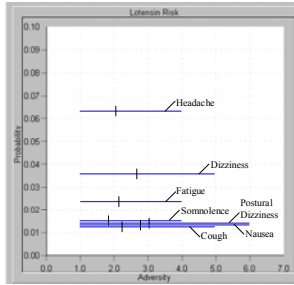
Quality of life

Not always clear which scale is best (e.g. Slovic 1999)

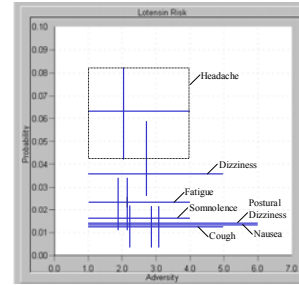
Ordinal ranking sidesteps the scales problem

Ask experts: "On a scale of 1 to 7, how bad is it if..."

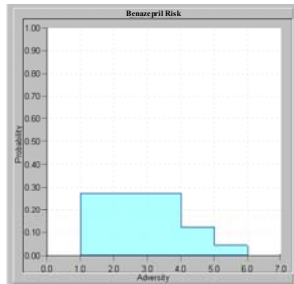
Uncertainty in adversity



Combining uncertain frequency and adversity



An image of risk



When does risk perception vary?

In the presence of uncertainty

Precautionary or evidentiary

When experts tell the risk

Consensus or inclusion

Trust in competence

Trust in motive

When risk is imposed

More or less uncertainty is relevant

Equity, fairness, justice

Attitudes

Quantify differences in risk perception

Four attitude parameters

Burden of proof

Dispute tolerance

Uncertainty in adversity

Uncertainty in frequency

A screenshot of the "Attitudes" software interface. It shows four parameters, each with a slider and a numerical value: Burden of proof (0.50), Dispute tolerance (0.50), Uncertainty display (Adversity 0.50), and Frequency (0.50). The interface includes buttons for "Add", "Delete", "Cancel", "OK", and "Help".

Attitudes

Burden of proof

Prove risk or prove safety?

Trust experts' motives

Which experts to display?

Dispute tolerance

Trust experts' competence

How much uncertainty?

Uncertain adversity

Are the harms unknown?

Are harms imposed?

Uncertain frequency

Strength of proof required

A screenshot of the "Attitudes" software interface, identical to the one in the previous slide, showing four parameters: Burden of proof (0.50), Dispute tolerance (0.50), Uncertainty display (Adversity 0.50), and Frequency (0.50). The interface includes buttons for "Add", "Delete", "Cancel", "OK", and "Help".

Case study: Cox 2 inhibitors

Data from five studies

VIOXX 6 month trials for FDA approval

VIGOR

CLASS

APPROVe

APC

How do stakeholders perceive the risk?

Industry, FDA, consumer groups

Adversity survey

Adverse Reaction	min	mean	max
Esophageal injury	2.00	3.43	5.00
Duodenal ulcer	3.00	3.86	5.00
Ischemic heart disease	4.00	4.36	5.00
Coronary artery disease	4.00	4.43	6.00
Transient ischemic attack	3.00	4.46	7.00
Angina pectoris	3.00	4.50	6.00
Unstable angina	3.00	5.14	7.00
Coronary artery occlusion	4.00	5.54	7.00
Cerebrovascular accident	5.00	6.07	7.00
Myocardial infarction	5.00	6.07	7.00
Cardiac arrest	6.00	6.64	7.00

Informal poll, n=14, mostly MDs and RNs

Data from 6 mos. studies

Rofecoxib data from Table 52 6 mos. studies and from Tables 7 and 14

N	Adverse Reaction	obs	freq	Confidence limits		(method)
				L1	L2	
Rofecoxib 25						
181	Esophageal injury	18	0.1107	0.0623	0.1591	reported
186	Duodenal ulcer	7	0.0410	0.0112	0.0707	reported
879	Myocardial infarction	2	0.0023	0.0000	0.0052	binomial
879	Coronary artery disease	2	0.0023	0.0000	0.0052	binomial
879	Angina pectoris	3	0.0034	0.0000	0.0052	binomial
879	Transient ischemic attack	3	0.0034	0.0000	0.0052	binomial
Rofecoxib 50						
176	Esophageal injury	22	0.1416	0.0865	0.1967	reported
178	Duodenal ulcer	12	0.0731	0.0331	0.1130	reported
379	Cerebrovascular accident	3	0.0079	0.0018	0.0317	binomial
379	Transient ischemic attack	1	0.0026	0.0000	0.0121	binomial
Ibuprofen						
164	Esophageal injury	15	0.1187	0.0613	0.1760	reported
167	Duodenal ulcer	42	0.2769	0.2043	0.3495	reported
377	Angina pectoris	2	0.0053	0.0018	0.0318	binomial
Placebo						
155	Esophageal injury	10	0.0927	0.0354	0.1500	reported
158	Duodenal ulcer	11	0.0992	0.0412	0.1573	reported
371	Myocardial infarction	2	0.0054	0.0018	0.0321	binomial
371	Unstable angina	1	0.0027	0.0000	0.0124	binomial

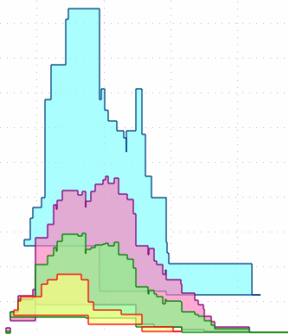
These data are from the FDA Vioxx approval web site
http://www.fda.gov/cder/foi/nda/09/02/21042_s2_vioxx.htm
 accessed 1/9/2005
 Medical reviews parts 7 and 23

VIGOR

N	Adverse Reaction	obs	freq	Confidence limits		(method)
				L1	L2	
Rofecoxib 50						
4047	all PUB	56	0.0138	0.0105	0.0180	poisson
4047	complicated PUB	16	0.0040	0.0023	0.0064	poisson
4047	Cerebrovascular accident	11	0.0027	0.0014	0.0049	poisson
4047	Myocardial infarction	20	0.0049	0.0030	0.0076	poisson
4047	Unstable angina	5	0.0012	0.0004	0.0029	poisson
4047	Transient ischemic attack	2	0.0005	0.0001	0.0018	poisson
4047	Cardiac arrest	3	0.0007	0.0002	0.0022	poisson
Naproxin						
4049	all PUB	121	0.0299	0.0299	0.0299	normal
4049	complicated PUB	37	0.0091	0.0064	0.0126	poisson
4029	Cerebrovascular accident	9	0.0022	0.0010	0.0042	poisson
4029	Myocardial infarction	4	0.0010	0.0003	0.0025	poisson
4029	Unstable angina	3	0.0007	0.0002	0.0022	poisson
4029	Cardiac arrest	4	0.0010	0.0003	0.0025	poisson

Vigor study, data from FDA Advisory Committee Briefing Document
 NDA 21-042, s007 VIOXX Gastrointestinal Safety February 8, 2001
 95% CI, poisson for events <100, normal for events >100

RAMAS[®] Risk Imaging



Directions for future work

2005 watershed in data availability

Data from each study are highly uncertain

How will these data be perceived by stakeholders?

Attitude characterization methods

Can we move from informal “philosophizing” to more rigorous methodology?

Derive stereotypes directly from data

Test predictive power retrospectively

Incorporating benefits into profiles

Acknowledgments

The research was initiated and supported by David Slavin of Pfizer, Inc., under the risk technologies program of Pfizer Global Research and Development. This collaborative applied risk project includes risk management centers, risk perception researchers, risk communication researchers, epidemiologists, clinicians, and philosophers. The authors wish to thank Resit Akçakaya, David-Olivier Azulay, Baruch Fischhoff, Janos Hajagos, Ragnar Löfstedt, David Myers, Jack Ostroff, Sharon Pochron, Christine Schlichting and Maureen Wescott for useful discussions. Thanks to Janos Hajagos, Natalya Obushenko and Anna Sokol for rewriting the risk imaging software. Some methods used were developed under support from the National Cancer Institute, NIH, under grant 9R44CA81741-02 to Applied Biomathematics.



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