Understanding Risk and Uncertainty: Making Decisions for Complex Problems

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How Do You Study Decision Making Under Uncertainty?

Decision Science: Integrated Study of

How people should make decisions
(normative analysis)

How people do make decisions
(descriptive research)

How to help people make better decisions
(prescriptive interventions)

A non-disciplinary field, with contributions from

psychology
economics
philosophy
sociology
operations research
neuroscience
political science
…

Intellectual Roots

Ramsey/von Neumann & Morgenstern

utility theory

Raiffa/Edwards

decision analysis

Simon/March/Cyert

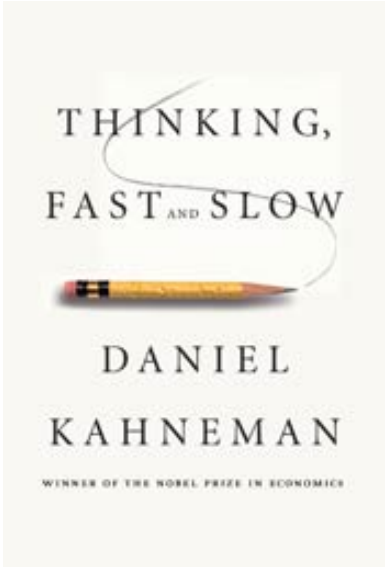
bounded rationality

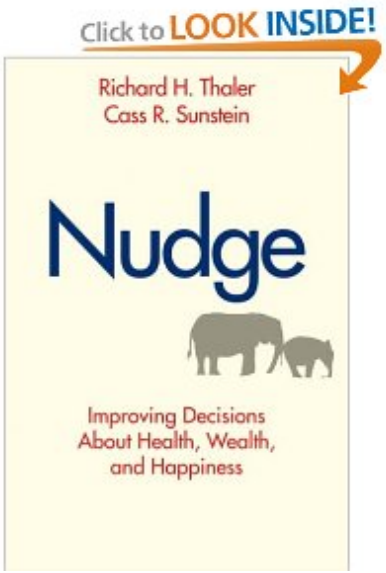
Tversky & Kahneman

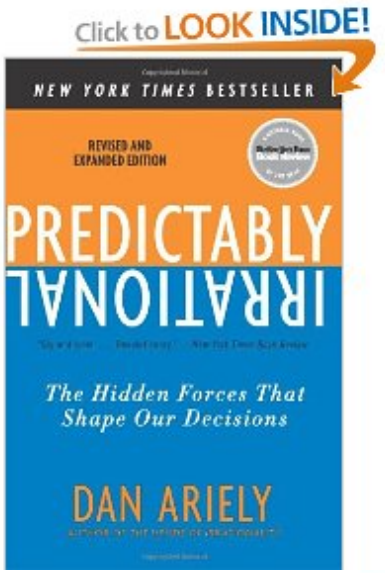
heuristics and biases

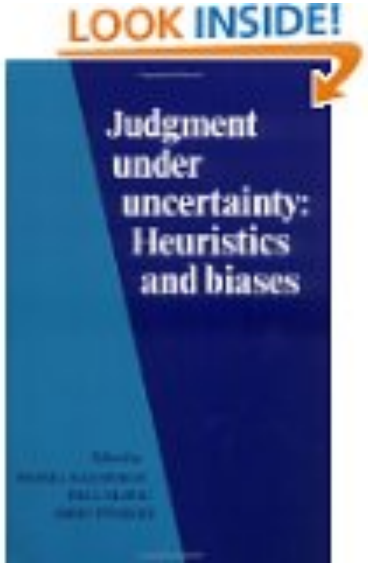
prospect theory

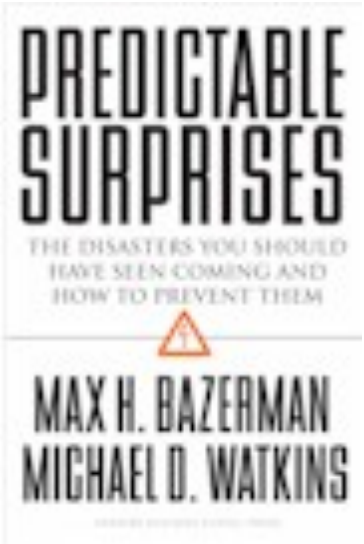
Some of Our Colleagues' Books

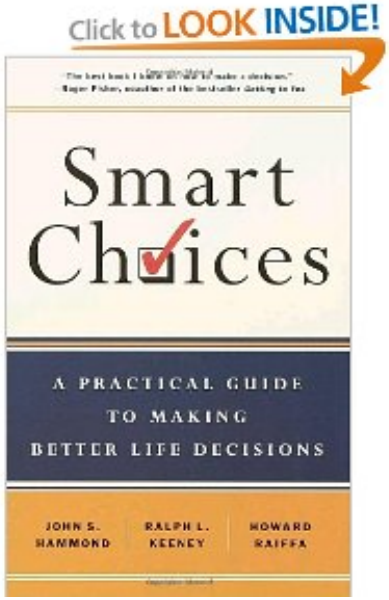




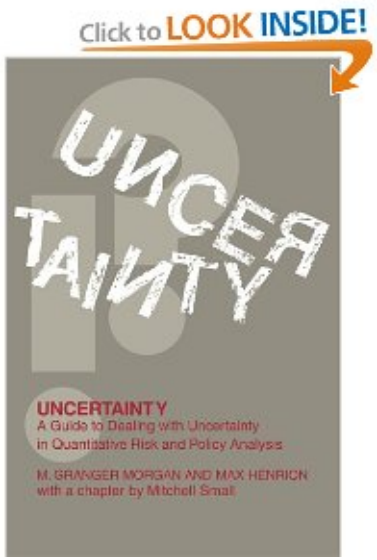


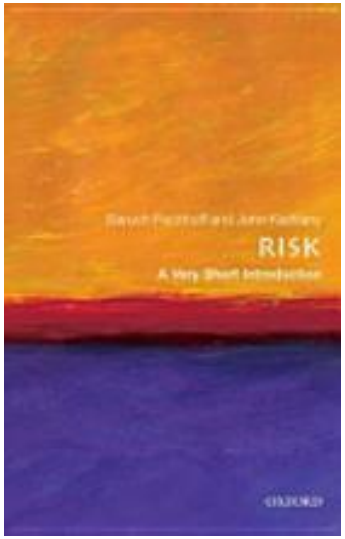


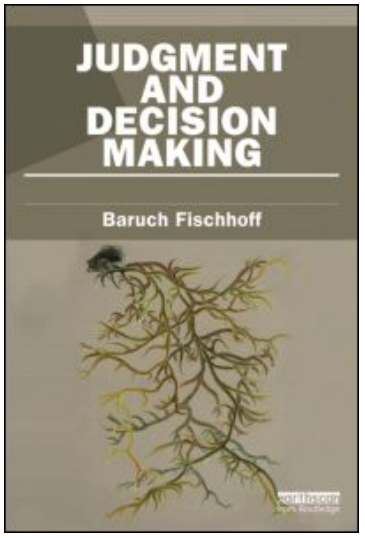


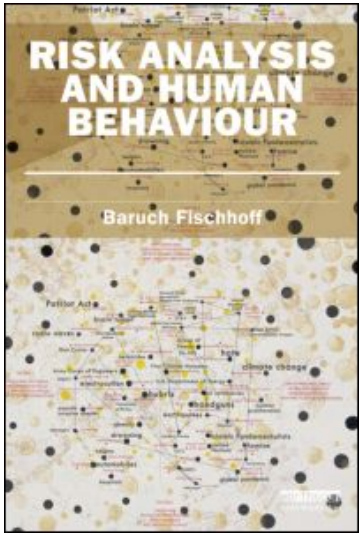


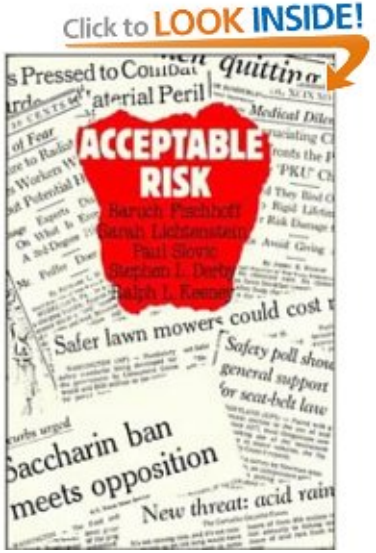
Some of Our Books

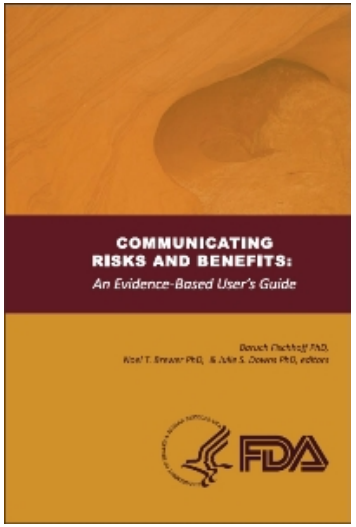




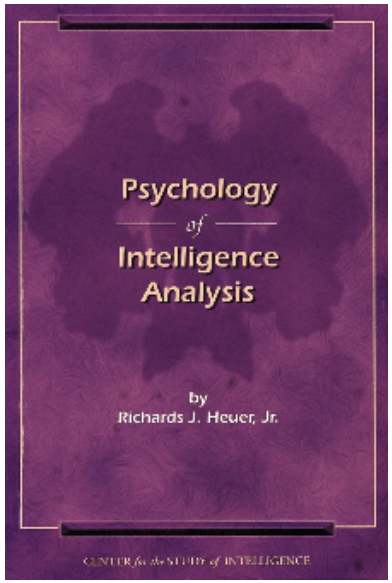


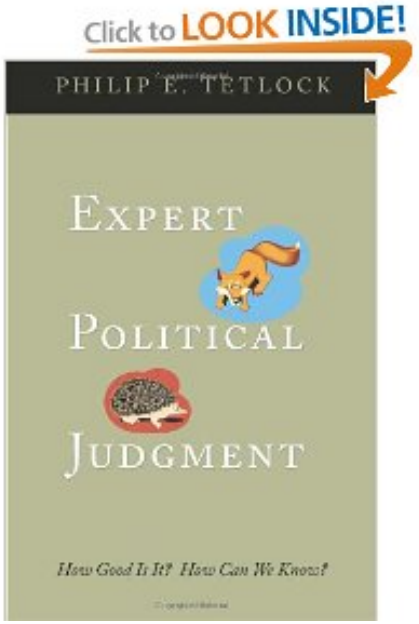


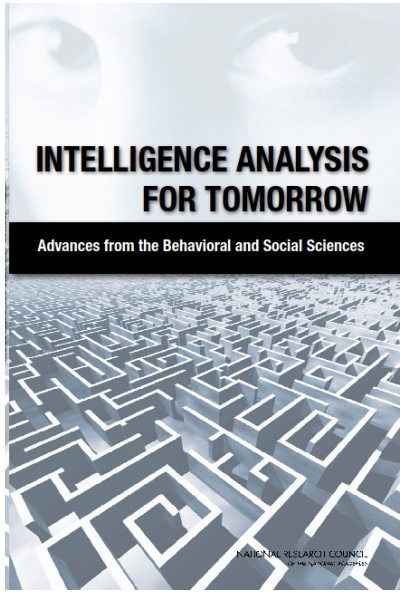


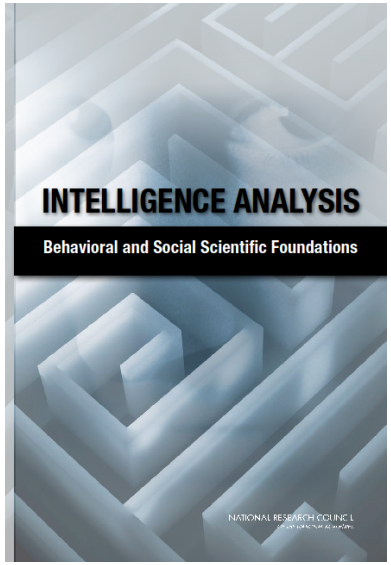


Some on Intelligence Analysis









Some Results

Decision Science Finds That

Decision making follows simple principles.

Some Principles of Judgment

People are good at tracking what they see, but not at detecting sample bias.

People have difficulty projecting non-linear trends.

People have limited ability to evaluate the extent of their own knowledge.

People have difficulty imagining themselves in other visceral states.

Transient emotions can affect perceptions, perhaps enough to tip close decisions.

Some Principles of Choice

People consider the return on their investment in making decisions.

People dislike uncertainty.

People confuse ignorance and stupidity.

People are insensitive to opportunity costs.

People are prisoners to sunk costs, hating to recognize losses.

People may not know what they want, especially with novel questions.

Decision Science Finds That

Decision making follows simple principles.

Decision Science Finds That

Decision making follows simple principles.

However,

- the set of principles is large,
- the contextual triggers are subtle, and
- the interactions are complex

As a result, decision-specific research is needed.

Decision Science as an Engineering Science

Applying basic analytical and behavioral principles, in conjunction with subject matter expertise, to problem solving and systems design.

With the Applications Essential to Scientific Progress

Applied basic science

do we have predictions?

are they accurate?

Basic applied science

are we seeing something new?

can we domesticate it for basic research?

Alan Baddeley

Some of Our Applications

plague
perchloroethylene
LNG
climate change
detergent
breast cancer
nuclear explosions
herpes (stigma)
xenotransplantation
smart meters

domestic radon
methylene chloride
EMF
UXO
violent radicalization
breast implants
nuclear power in space
Plan B (morning after pill)
neonates
vaccines (anthrax, MMR)

Some Typical Projects

Carotid Endarterechtomy

Problem: medical informed consent

Normative: value-of-information analysis for ability of risk facts to affect patient decisions

Descriptive: [no trustworthy knowledge]

Prescriptive: focus on probabilities of death, stroke, and facial paralysis; on meaning of paralysis

Merz, J., Fischhoff, B., Mazur, D.J., & Fischbeck, P.S. (1993). Decision-analytic approach to developing standards of disclosure for medical informed consent. *Journal of Toxics and Liability, 15*, 191-215

Paint Stripper

Problem: chemical labeling standards

Normative: diffusion-uptake model, predicting cumulative dose and peak levels

Descriptive: users willing to act, but confused over method effectiveness

Prescriptive: voluntary control perhaps impossible, without mandatory label design

Riley, D.M., Fischhoff, B., Small, M., & Fischbeck, P. (2001). Evaluating the effectiveness of risk-reduction strategies for consumer chemical products. *Risk Analysis, 21*, 357-369

Sexual Assault

Problem: confident, universal, contradictory advice

Normative: meta-analysis of effectiveness studies

Descriptive: nuanced belief structure, differing goals, exaggerated effectiveness

Prescriptive: realistic expectations, societal responsibility, effectiveness research

Fischhoff, B. (1992). Giving advice: Decision theory perspectives on sexual assault. *American Psychologist, 47*, 577-58

Cryptosporidium

Problem: emergency warning system

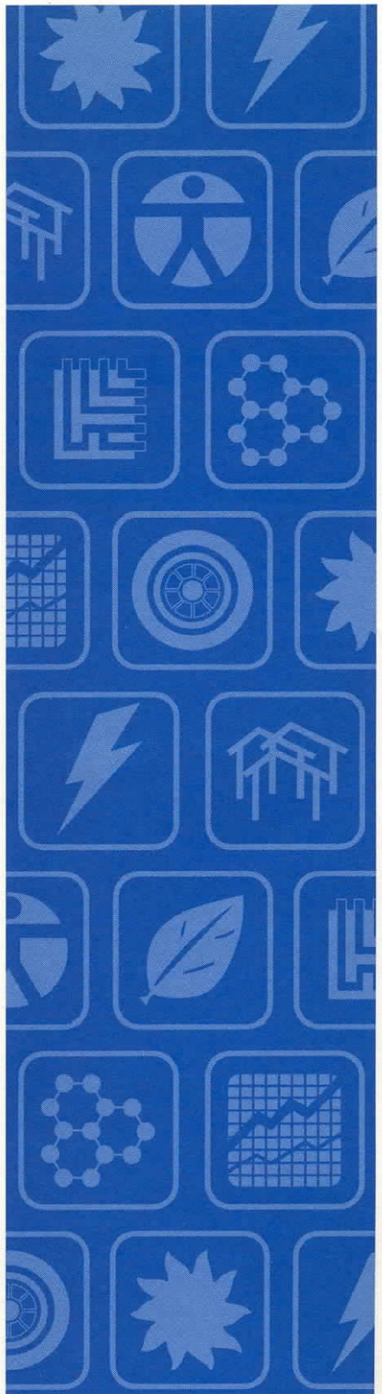
Normative: model of system performance, including detection, coordination, and consumer behavior

Descriptive: little knowledge in affected communities, useless knowledge among vulnerable individuals

Prescriptive: abandon warning system, provide services for vulnerable

Casman, E., Fischhoff, B., Palmgren, C., Small, M., & Wu, F. (2000). Integrated risk model of a drinking waterborne Cryptosporidiosis outbreak. *Risk Analysis, 20*, 493-509

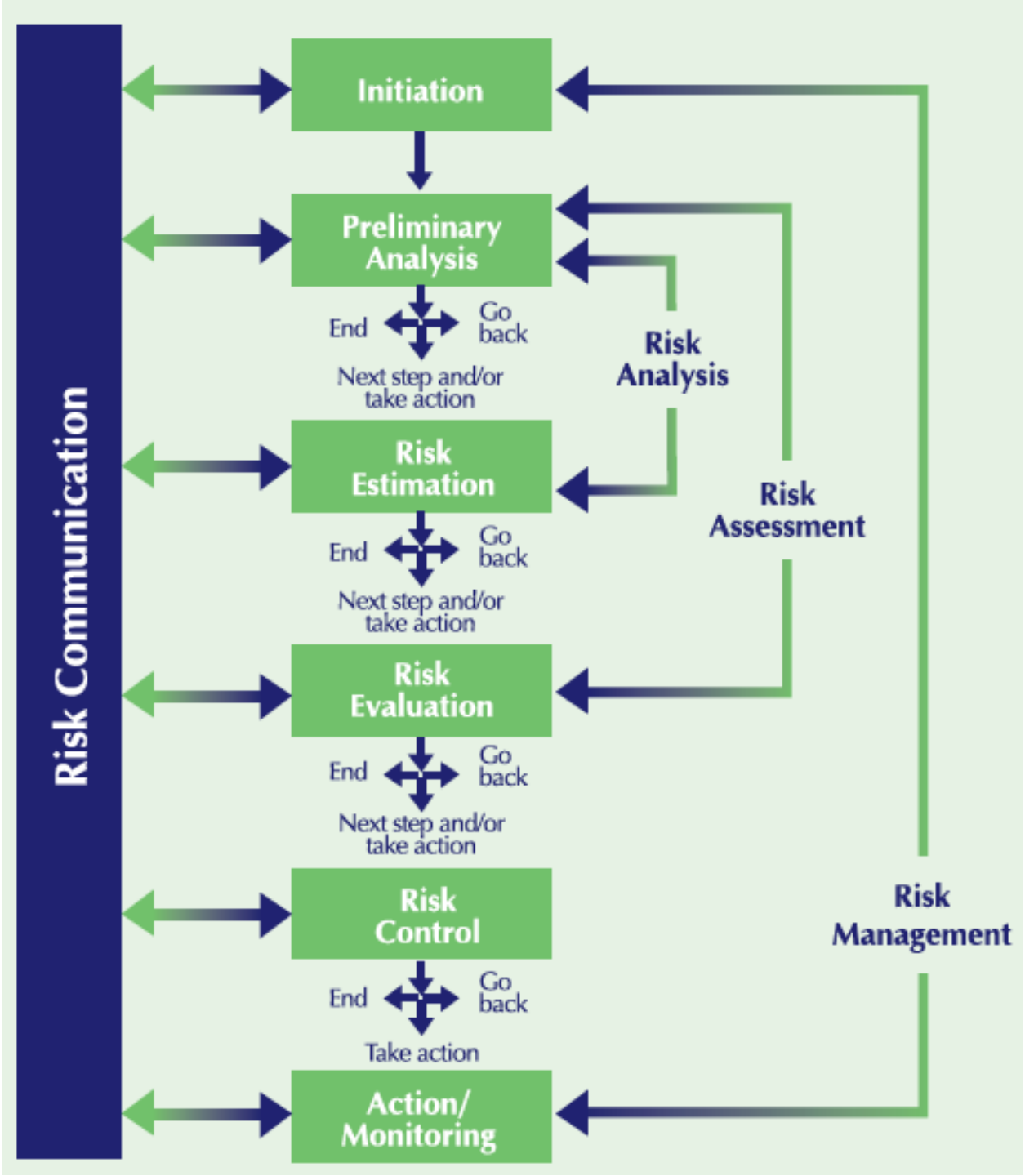
Getting Organized



CAN/CSA-Q850-97

Risk Management: Guideline for Decision-Makers

A National Standard of Canada


Risk Communication
Initiation
Preliminary Analysis
End
Go back
Next step and/or take action
Risk Analysis
Risk Estimation
End
Go back
Next step and/or take action
Risk Assessment
Risk Evaluation
End
Go back
Next step and/or take action
Risk Control
End
Go back
Take action
Risk Management
Action/ Monitoring

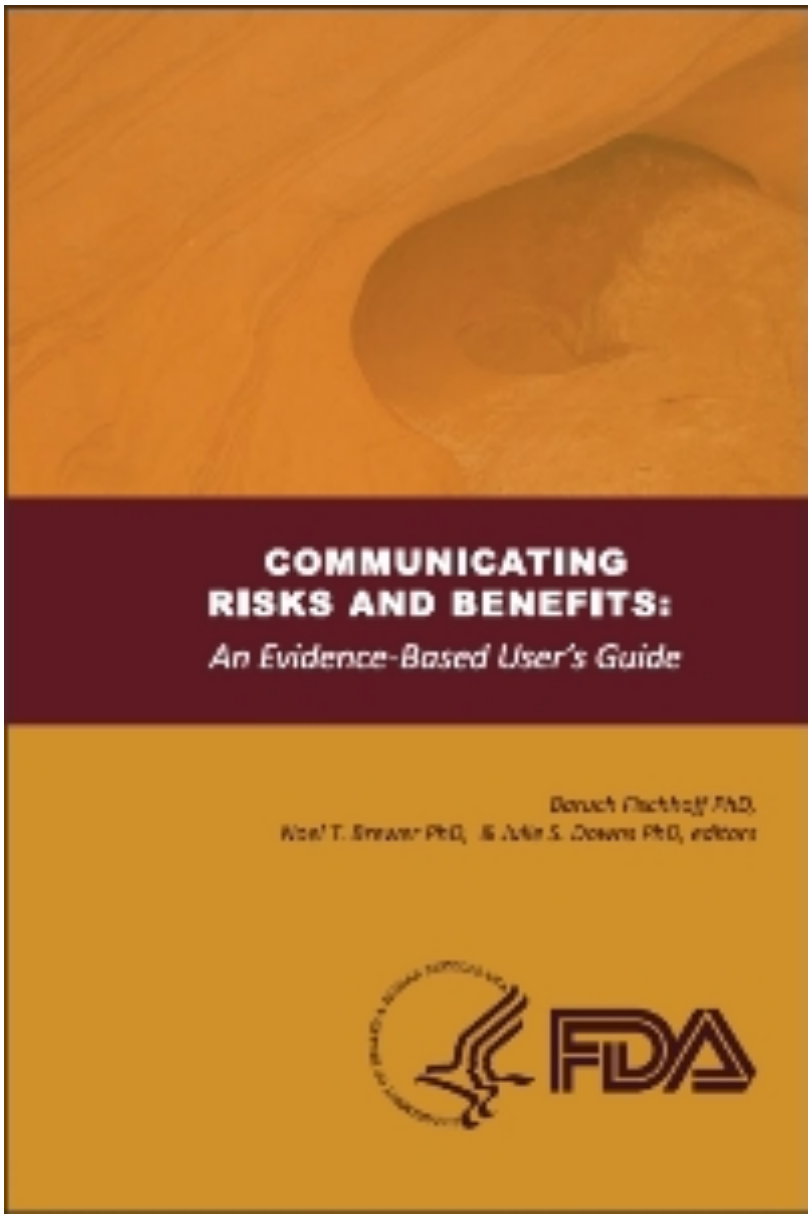
FDA'S
STRATEGIC PLAN
FOR
RISK COMMUNICATION

Fall, 2009

Recommendations for Managing Emerging Events

Have a consistent policy in all domains
Provide useful, timely information
Address: risks and benefits, uncertainty, personal actions, FDA actions
Audience needs should drive agency analyses
Use standard formats; evaluate routinely
Consider needs of diverse populations

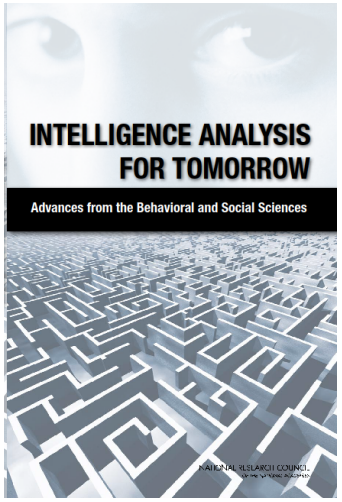
http://www.fda.gov/oc/advisory/OCRCACACpg.html



http://www.fda.gov/AboutFDA/ReportsManualsForms/Reports/ucm268078.htm

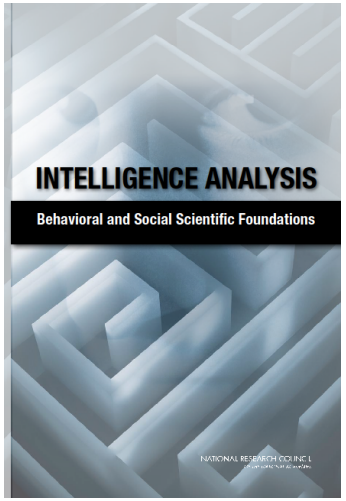
Decision Science in Intelligence Analysis

Consensus Report



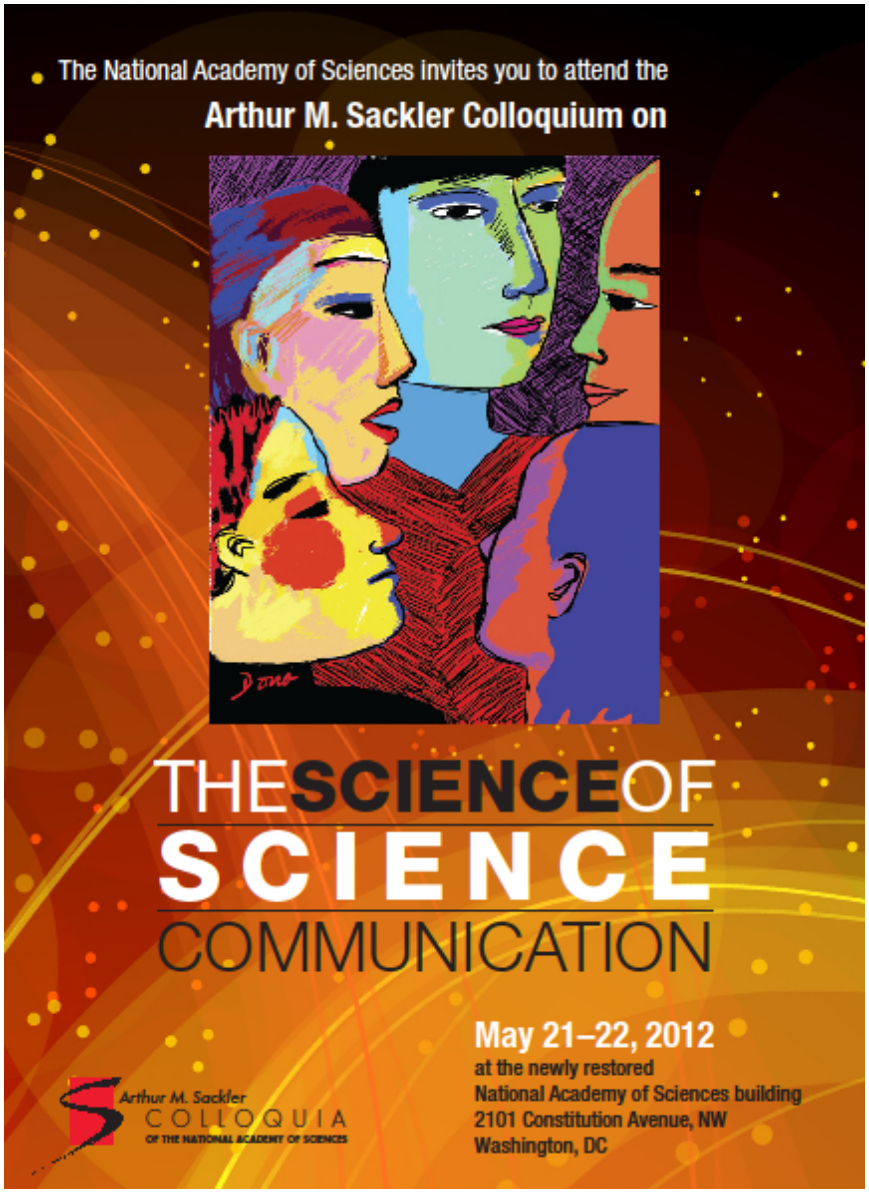
Analysis, Recommendations, & Immediate Actions (100 pages)

Collection of Papers



Introduction to Methods and Evidentiary Base (350 pages)

Intelligence Analysis for Tomorrow: http://www.nap.edu/catalog.php?record_id=13040
Intelligence Analysis: Behavioral and Social Scientific Foundations: http://www.nap.edu/catalog.php?record_id=13062



http://www.nasonline.org/programs/sackler-colloquia/upcoming-colloquia/science-communication.html

Applications Require

Domain specialists
Risk and decision analysts
Behavioral scientists
Policy/system analysts

Decision Science Resource Centers

Provide publication-quality scientific support for designing, implementing, and empirically evaluating solutions.

Decision Science Resource Centers

Provide publication-quality scientific support for designing, implementing, and empirically evaluating solutions.

-- quality assurance
-- economies of scope
-- pool lessons learned
-- anticipate problems
-- involve academic researchers

Books

Ariely, D. (2008). *Predictably irrational*. New York: Harper Collins.

Bazerman, M.H., & Watkins, H.D. (2004). *Predictable surprises*. Boston: Harvard Business School.

Fischhoff, B. (2011). *Judgment and decision making*. London: Earthscan.

Fischhoff, B. (2011). *Risk analysis and behavioral research*. London: Earthscan.

Fischhoff, B., Brewer, N., & Downs, J.S. (eds.). (2011). *Communicating risks and benefits: An evidence-based user's guide*. Washington, DC: Food and Drug Administration.

Fischhoff, B., & Chauvin, C. (eds.). (2011). *Intelligence analysis: Behavioral and social science foundations*. Washington, DC: National Academy Press.

Fischhoff, B., & Kadvany, J. (2011). *Risk: A very short introduction*. Oxford: Oxford University Press.

Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S. L. & Keeney, R. L. (1981). *Acceptable risk*. New York: Cambridge University Press.

Hammond, J.S., Keeney, R., & Raiffa, R. (1998). *Smart choices*. Boston: Harvard Business School.

Heuer, R. (1999). *Psychology of intelligence analysis*. CIA: Center for Intelligence Analysis.

Kahneman, D. (2011). *Thinking fast and slow*. New York: Farrar Straus & Giroux.

Kahneman, D., Slovic, P., & A. Tversky, A. (Eds.). *Judgment under uncertainty: Heuristics and biases* (pp. 422-444). New York: Cambridge University Press.

Morgan, M.G., Fischhoff, B., Bostrom, A., & Atman, C. (2001). *Risk communication: The mental models approach*. New York: Cambridge University Press.

Morgan, M.G., & Henrion, M. (1990). *Uncertainty*. New York: Cambridge University Press.

National Research Council. (2011). *Intelligence analysis for tomorrow*. Washington, DC: National Academy Press.

Raiffa, H. (1968). *Decision analysis*. Reading, MA: Addison-Wesley.

Tetlock, P. (2005). *Expert political judgment*. Princeton: Princeton University Press.

Research Articles

Bruine de Bruin, W., Parker, A., & Fischhoff, B. (2007) Individual differences in adult decision-making competence (A-DMC). *Journal of Personality and Social Psychology. 92*, 938-956.

Fischhoff, B. (1992). Giving advice: Decision theory perspectives on sexual assault. *American Psychologist*, 47, 577-588.

Fischhoff, B., Atran, S., & Fischhoff, N. (2007). Counting casualties: A framework for respectful, useful records. *Journal of Risk and Uncertainty, 34*, 1-19.

Fischhoff, B., Bruine de Bruin, W., Guvenc, U., Caruso, D., & Brilliant, L. (2006). Analyzing disaster risks and plans: An avian flu example. *Journal of Risk and Uncertainty*, 33, 133-151.

Lanir, Z., & Kahneman, D. (2006), An experiment in decision analysis in Israel in 1975. *Studies in Intelligence*, 50(4).