Expert Judgement

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The need for EJ… and the problem

- Complexity of society and environment plus need for timely response means we *cannot wait* for long term empirical studies…EJ is indispensable
- BUT
  - Non-structured EJ is not satisfactory
  - Structured EJ is not yet fully developed
  - Social, legal, governmental processes not attuned to the potential or properly calibrated to the limitations

So ….

… (societal) risk analysis needs good methodologies for expert judgement.

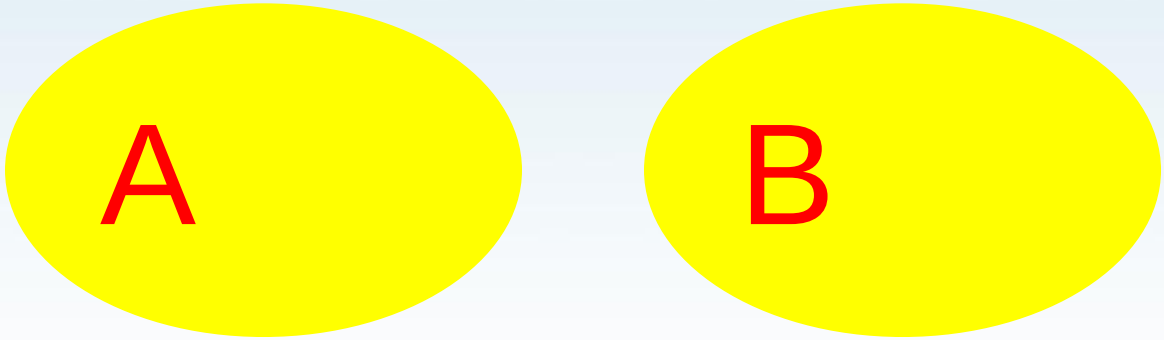
- Very multi-disciplinary: e.g.
  - Mathematical & statistical analysis
  - Behavioural issues in eliciting judgements
  - Political, Legal, Ethical issues
- and none of it is trivial and obvious…

Independence Preservation

- Ask experts E1 and E2 for their probabilities for events A and B
- E1 and E2 agree that A and B are probabilistically independent
- You agree that A and B are probabilistically independent
- E1 and E2 give you their probabilities for A and B
- A happens
- Do you change your probability for B?

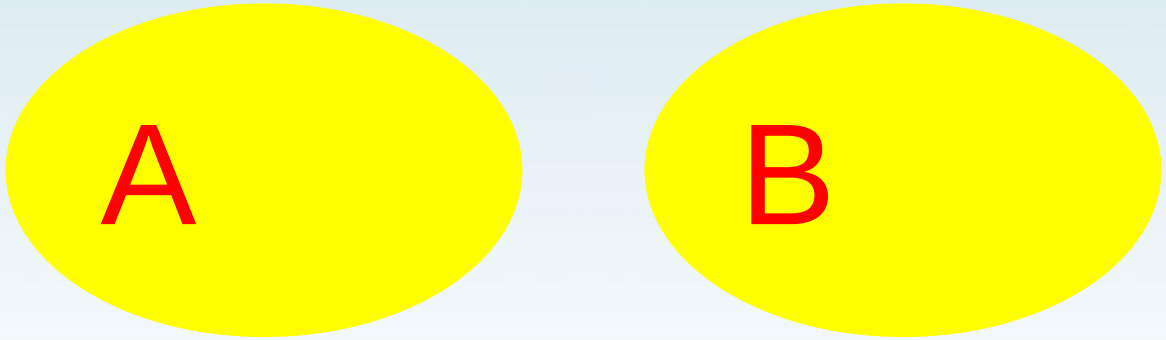
The system that you are observing

Not



The system that you are observing

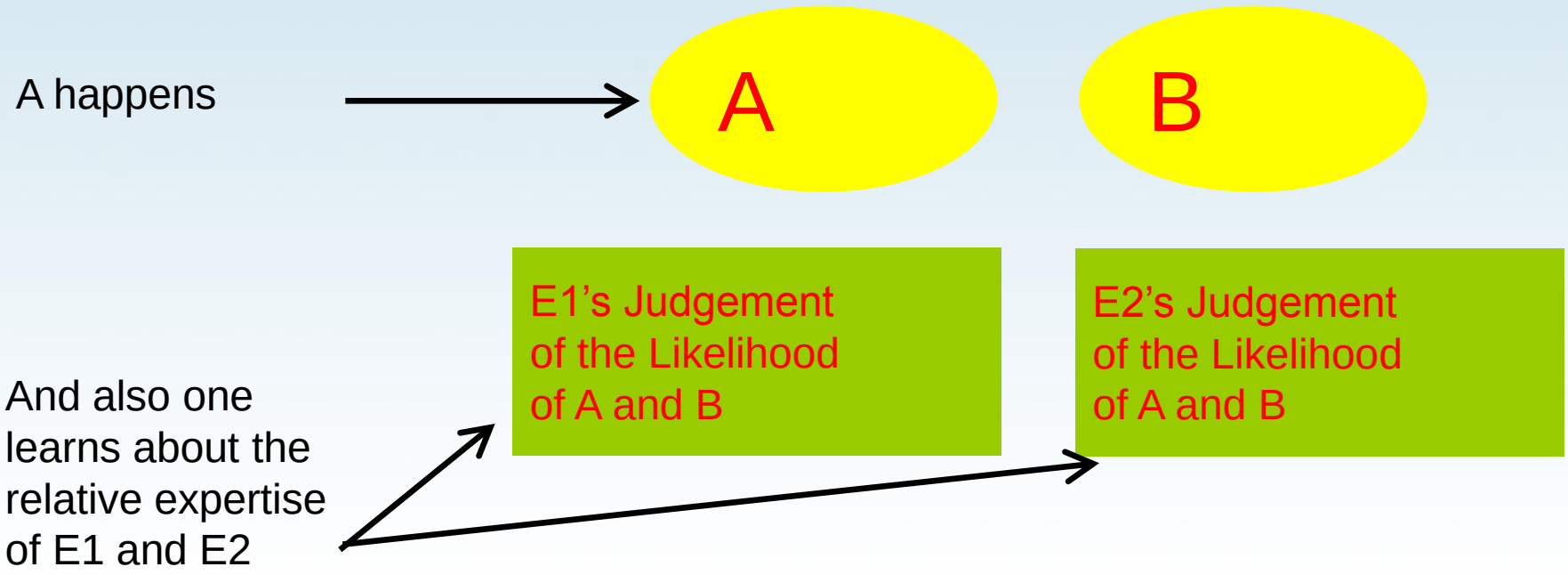
But



E1's Judgement of the Likelihood of A and B

E2's Judgement of the Likelihood of A and B

The system that you are observing



Independence preservation means that it is not possible to learn about expertise

What is transparently obvious isn't ...

- It is not easy to model uncertainty
- After three centuries or so, probability theory is coherent, conceptually sound
  - Some other theories are less sound or just plain dumb
- But introduce the different perspectives of several experts and there are still modelling, ethical and philosophical issues to resolve in the probabilistic modelling of expert judgement

Probability

Frequency — Degree of Belief

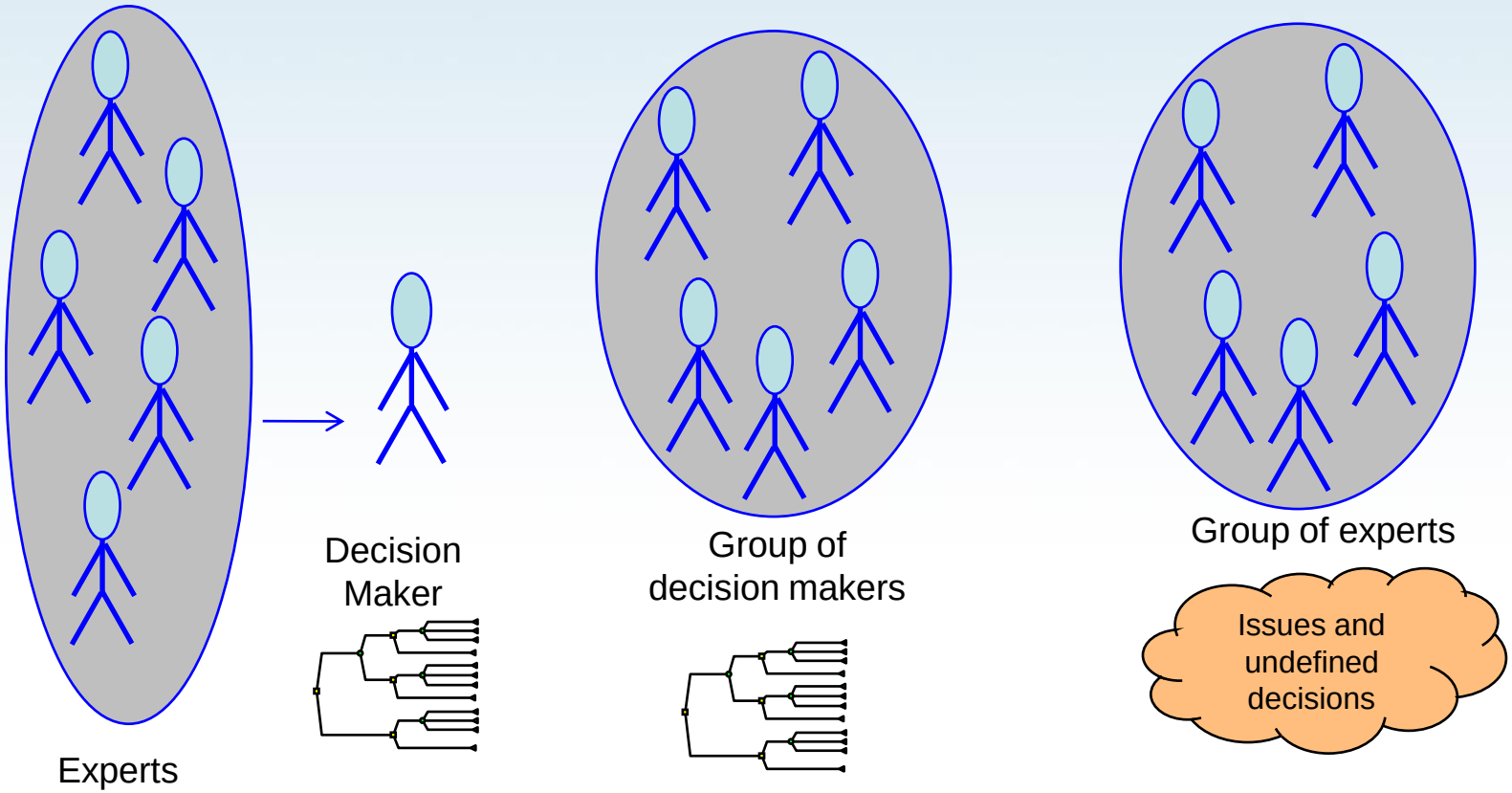
Statistical Methodology

Empirical objectivist	Logical objectivist	Subjective objectivist	Subjective subjectivitist

- Expert Judgements: Probability or Data?
- Whose probability is that ‘p’ in the model? Or is it just *the* probability?

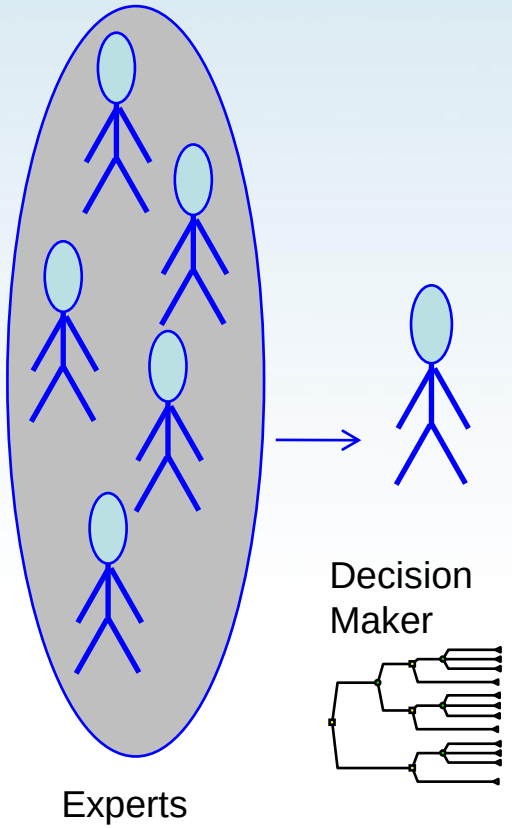
Group Consensus Probability Distributions
Bayesian Statistics 2, Valencia 1983

The Expert Problem	The Group Decision Problem	The Text-Book Problem



The Expert Problem

Linear Pools



$$P_{DM} = \sum_{e=1}^{E} w_e P_e , \quad P_{DM} = \prod_{e=1}^{E} P_e^{w_e} \quad \text{or}$$

$$P_{DM} = \phi(P_1, P_2, \ldots, P_E).$$

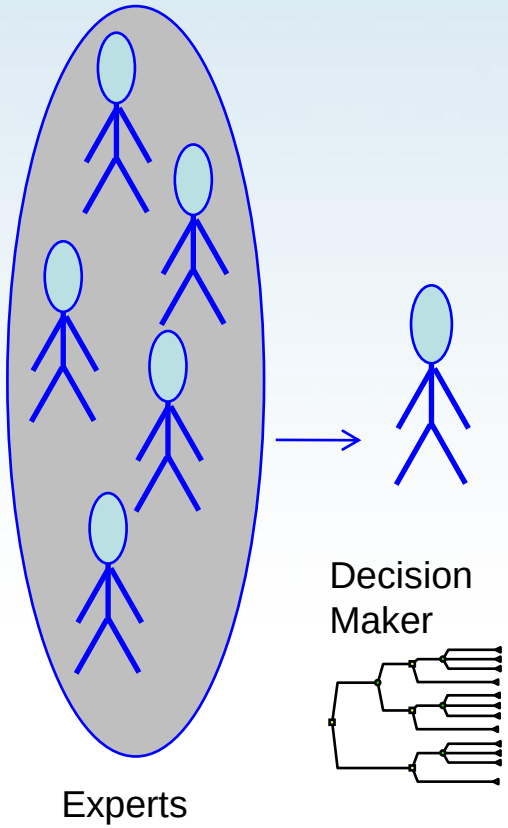
- Expert judgement are taken as probabilities
- Essentially a weighted mean
  - arithmetic, geometric, …
- Weights defined from
  - DM's judgement
  - Equal weights (Laplace, equal pay)
  - Social networks
  - Calibration sets

Transparently Desirable Properties of Opinion Pools

- Independence preservation
  - Independence preserved by aggregation
- Marginalisation
  - Marginalisation and aggregation commute
- Zero Preservation Property
  - All agree on impossibility $\Rightarrow$ aggregate impossibility
- External Bayesian
  - Bayesian updating commutes with aggregation
- Strong Setwise Function
  - Aggregate probability of A depends only on experts' judgements of A

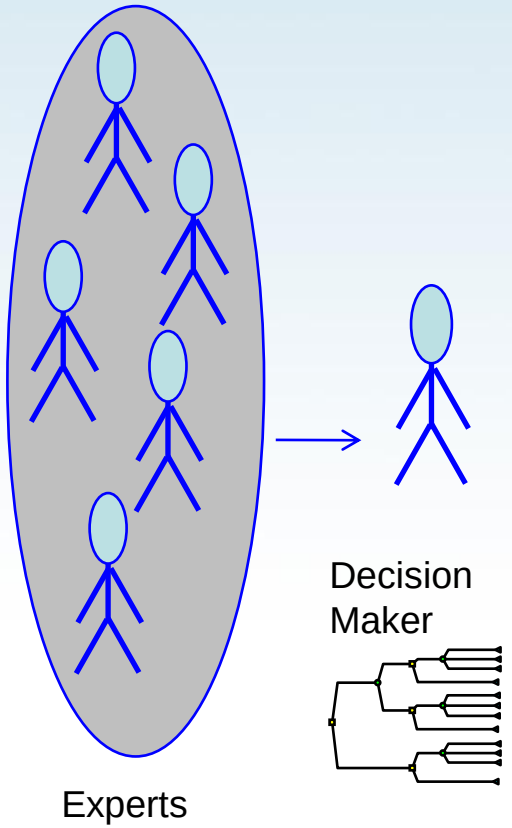
The Expert Problem

Measure the probability dist^{n} from expert *data*



- Ask experts for probabilities, means, whatever and *estimate*/*fit* the distribution
- O'Hagan and co-workers
- Sheffield Elicitation Framework (SHELF)
- Often elicit from a group:
  - behavioural elicitation – see below

The Expert Problem



Bayesian Approach

$P_{DM}(\theta|\mathbf{Q}) \propto P_{DM}(\mathbf{Q}|\theta) \times P_{DM}(\theta)$

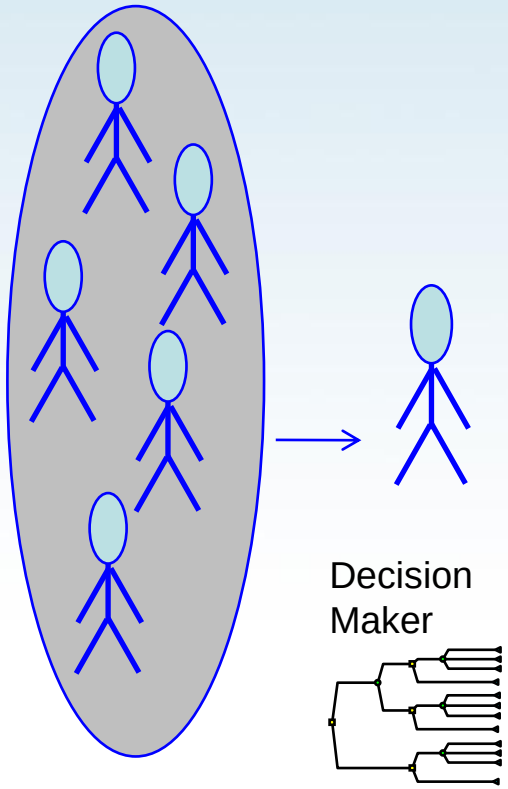
$P_{DM}(\bullet)$ Decision maker's probabilities

θ unknown quantity

Q expert judgements

- Expert judgements are data to DM
- Calibration of experts; overconfident

The Expert Problem



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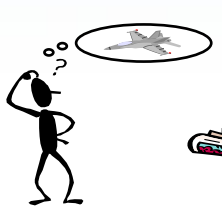
e.g.



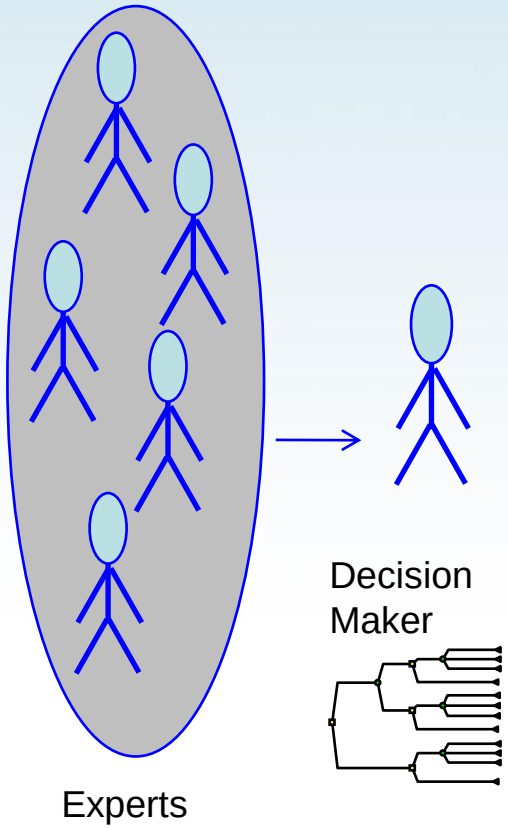
Imaginable

Recent

Dramatic

$\Rightarrow$ Bias & poor calibration

The Expert Problem



Bayesian Approach

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$P_{DM}(\bullet)$ Decision maker's probabilities

θ unknown quantity

Q expert judgements

- Expert judgements are data to DM
- Calibration of experts; overconfident
- Expert judgements are correlated
  - with each other's
  - with decision maker's

- Common science base
- Similar education
- Similar experiences

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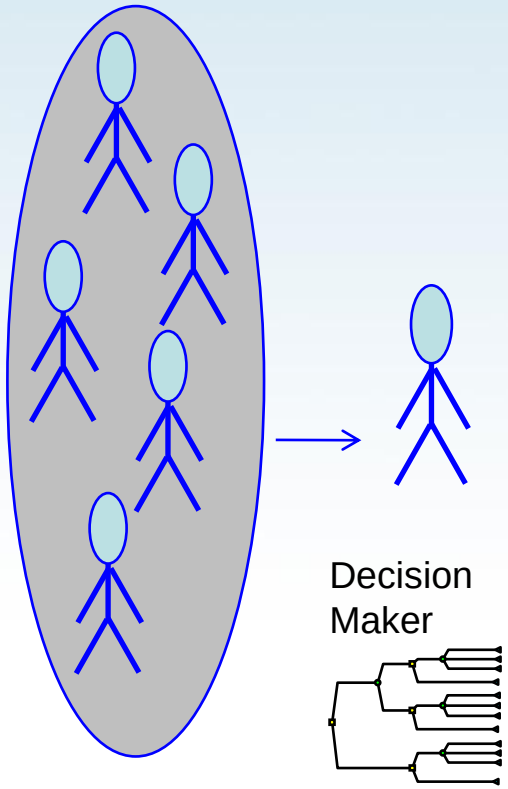
The Expert Problem



Bayesian Approach

$P_{DM}(\theta|\mathbf{Q}) \propto P_{DM}(\mathbf{Q}|\theta) \times P_{DM}(\theta)$

$P_{DM}(\bullet)$ Decision maker's probabilities

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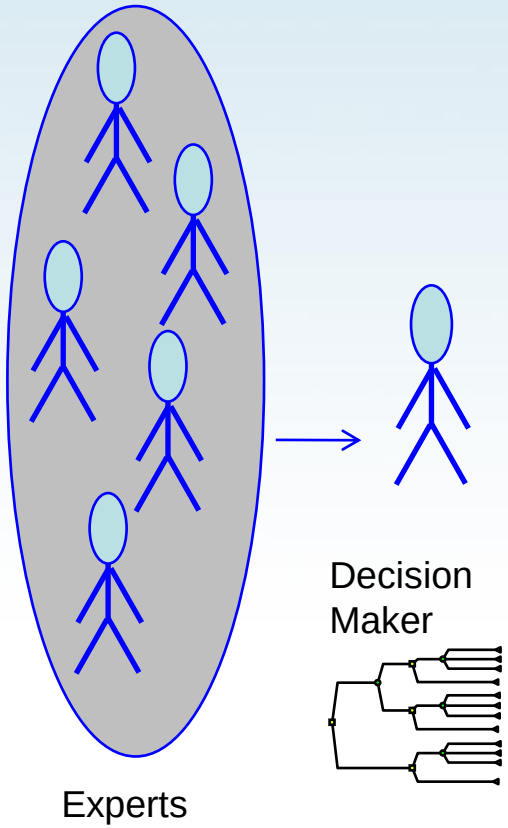
Q expert judgements

- Expert judgements are data to DM
- Calibration of experts; overconfident
- Expert judgements are correlated
  with each other's
  with decision maker's
- Social pressures, conflicts of interest, competition between experts

The Expert Problem



Bayesian Approach

$P_{DM}(\theta|\mathbf{Q}) \propto P_{DM}(\mathbf{Q}|\theta) \times P_{DM}(\theta)$

$P_{DM}(\mathbf{Q}|\theta)$ difficult to define:

- correlations
- scaling issues in **Q**

- Normal conjugate families (French, Lindley, Winkler, Wiper, ...)
  easy to work with correlations
- Non parametric approaches (Lichtendahl)
- Copulas (Jouini and Clemen)
- MCMC (Clemen and Lichtendahl)

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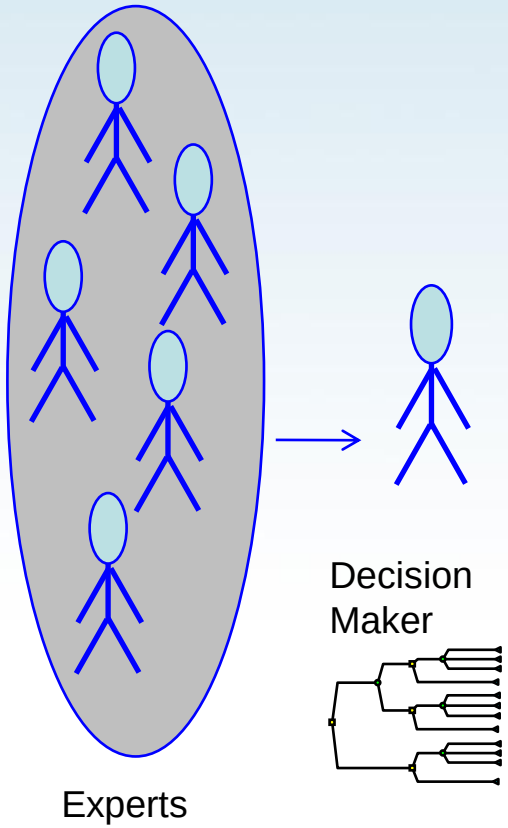
The Expert Problem

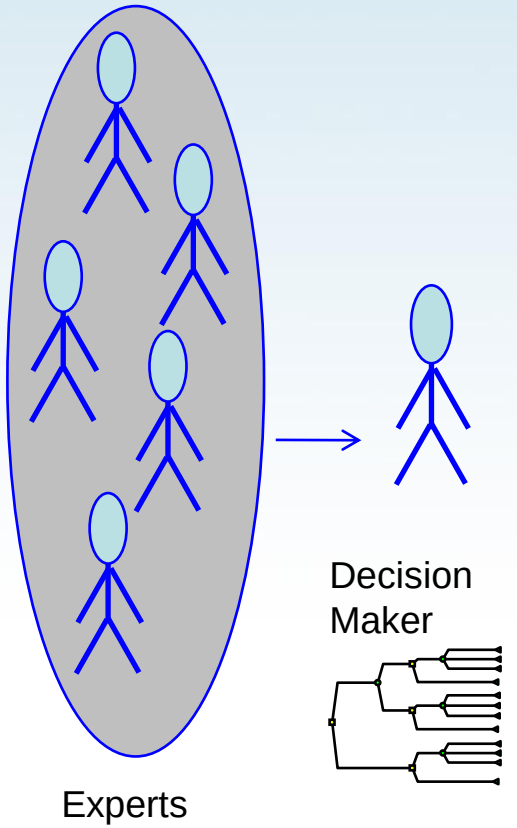


Behavioural aggregation:
Let the experts talk and agree a probability dist^n to give the decision maker

- Group pressure and conformity
- Facilitated consensus forming (Reagan-Cirincione, 1994)
- Structured or unstructured?
  - Delphi (Dalkey & Helmer 1963, Sackman 1975, Linstone & Turoff 1978, Rowe & Wright 1999)
  - Qualitative Controlled Feedback (Press 1978)
- Consensus single dist^n or maintain outliers?
- Web conferencing

The Expert Problem

What questions do we ask experts

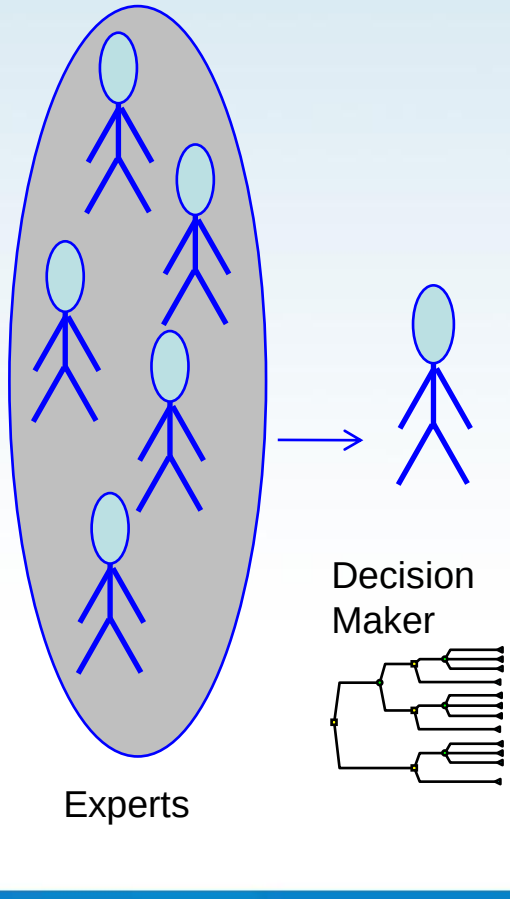


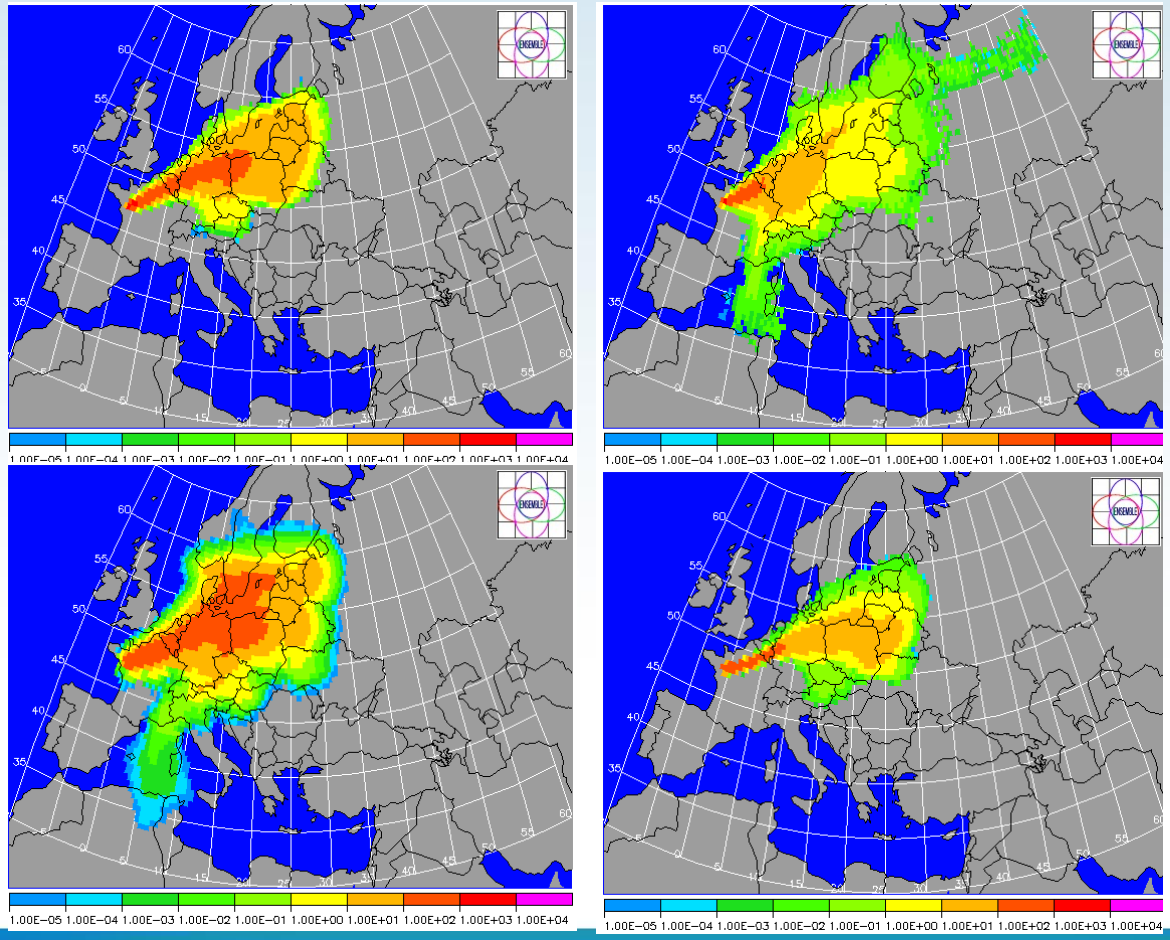
- Ask for observables
  - Must be observable for calibration
  - Model parameters are model dependent
- Actually often ask for:

  (expert judgement ⊗ model)
- CEC/USNRG study on accident consequence modelling
- ENSEMBLE

The Expert Problem

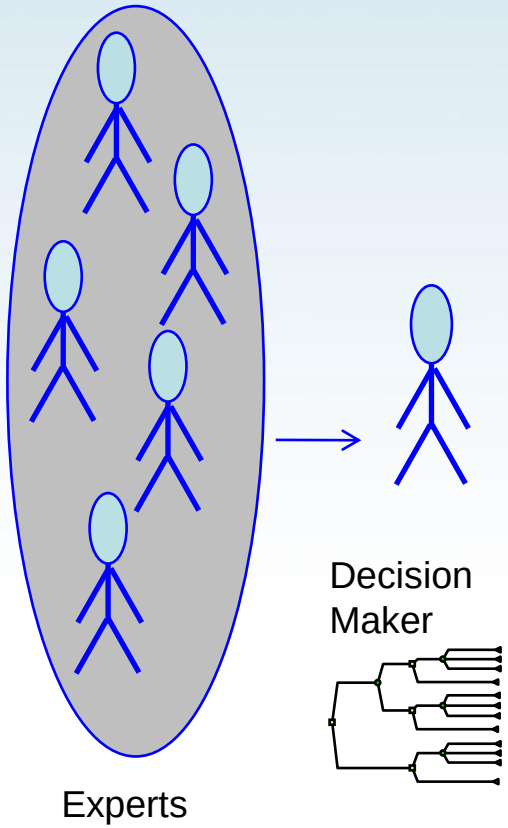
ENSEMBLE Project





The Expert Problem

What questions do we ask experts



- Ask for observables
  - Must be observable for calibration
  - Model parameters are model dependent
- Actually often ask for:

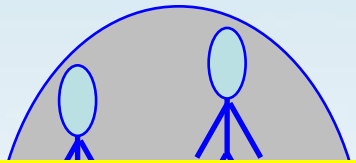
  (expert judgement ⊗ model)
- CEC/USNRG study on accident consequence modelling
- ENSEMBLE
- Pragmatic solution:

  Treat as expert judgement

  Apply Cooke's method

The Group Decision Problem

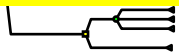
- combine individual $p_i(.)$ and $u_i(.)$ into group $p_g(.)$ and $u_g(.)$ then form group expected utility ranking.



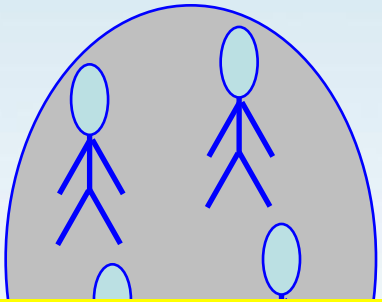
$(p_1(.), u_1(.)), (p_2(.), u_2(.)), \ldots (p_i(.), u_i(.)), \ldots (p_n(.), u_n(.))$

$(p_g(.), u_g(.))$

$$\int u_g(x)\, p_g(x)\, dx$$



The Group Decision Problem



- combine individual $p_i(.)$ and $u_i(.)$ into group $p_g(.)$ and $u_g(.)$ then form group expected utility ranking.
- individuals rank using their own expected utility ordering then vote

$(p_1(.), u_1(.)), (p_2(.), u_2(.)), \ldots (p_i(.), u_i(.)), \ldots (p_n(.), u_n(.))$

$\int u_1(x)p_1(x)dx$ $\int u_2(x)p_2(x)dx$ $\int u_i(x)p_i(x)dx$ $\int u_n(x)p_n(x)dx$

vote vote vote vote

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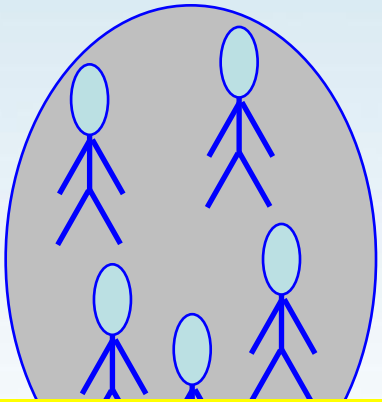
The Group Decision Problem



- combine individual $p_i(.)$ and $u_i(.)$ into group $p_g(.)$ and $u_g(.)$ then form group expected utility ranking.
- individuals rank using their own expected utility ordering then vote
- altruistic Supra Decision Maker

$$(p_1(.), u_1(.)), (p_2(.), u_2(.)), \ldots (p_i(.), u_i(.)), \ldots (p_n(.), u_n(.))$$

$$\int u_{sdm}(x)\, p_{sdm}(x)\, dx$$

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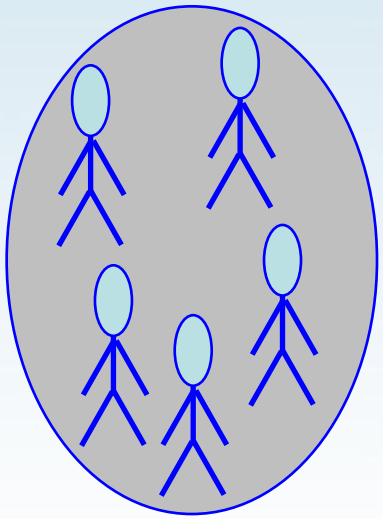
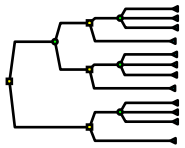
The Group Decision Problem



Group of decision makers



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Arrow's Theorem and related paradoxes and inconsistency results suggest that

Group decisions do not exist

Need to concentrate on process

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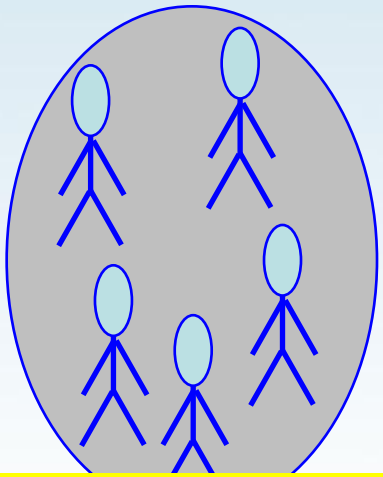
The Group Decision Problem



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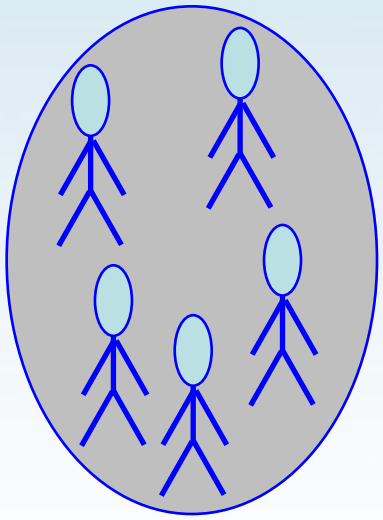
- individuals rank using their own expected utility ordering then vote
- altruistic Supra Decision Maker
- negotiation and bargaining processes

$(p_1(.), u_1(.)), (p_2(.), u_2(.)), \ldots (p_i(.), u_i(.)), \ldots (p_n(.), u_n(.))$

$Eu_1(x^*), Eu_2(x^*), \ldots Eu_i(x^*), \ldots, Eu_n(x^*)$

The Group Decision Problem

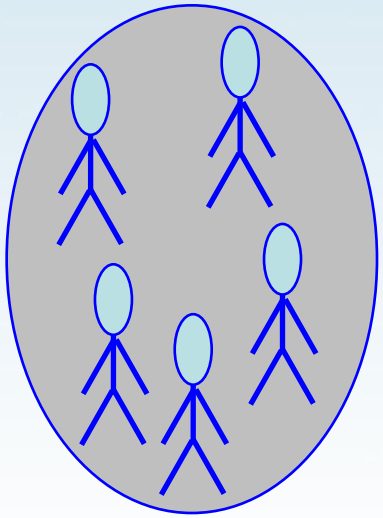


Group of decision makers

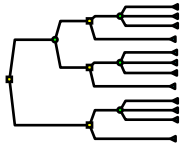
- combine individual $p_i(.)$ and $u_i(.)$ into group $p_g(.)$ and $u_g(.)$ then form group expected utility ranking.
- individuals rank using their own expected utility ordering then vote
- altruistic Supra Decision Maker
- negotiation and bargaining processes
- social process which translates individual decisions into an implemented action

- Decision conferences
- Sensitivity analysis around ‘reference’ decision or negotiation models
- Decision analysis as much about communication as about supporting decision making
- Might vote or might leave the actual decision to unspoken political and social processes

The Group Decision Problem



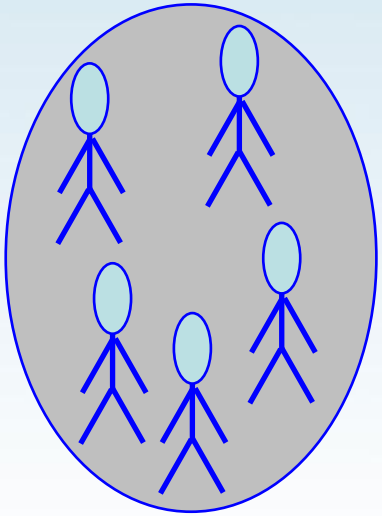
Group of
decision makers



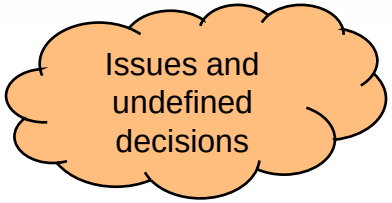
There are serious issues out there...

- The advent of the readily available computing means that algorithmic solutions to the Group Decision Problem are attractive.
- Few software developers and even fewer users know of the difficulties that Arrow raised.

The Textbook Problem

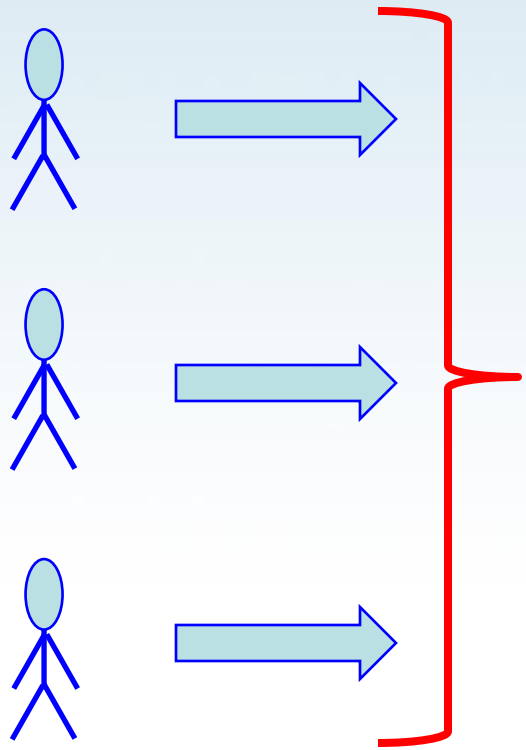


Group of experts



- How to present results to help in future as yet unspecified decisions
  - e.g. Asteroid impact
- How does one report with that in mind?
- Public participation and the web means that many stakeholders are seeking and using expert reports … whether or not they understand them
  - Behavioural issues
  - Probabilities versus frequencies (Gigerenzer)
  - Risk communication
  - Celebrity

Communication issues:
What the experts say

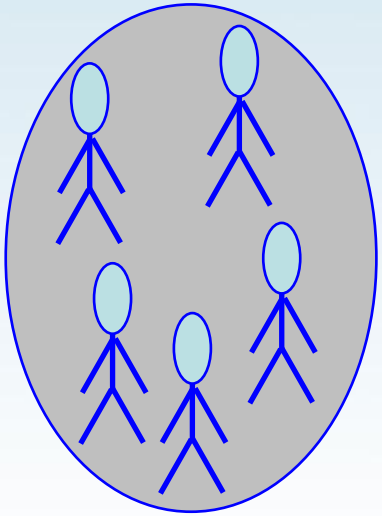


- The experts *broadcast* their views rather than respond to questions of (unknown) decision makers
- Experts are human

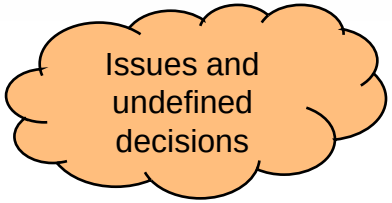
  $\Rightarrow$ Subject to 'psychological biases'
- Such biases *may* be avoided/reduced by careful elicitation protocols.
- But experts are also correlated
  - Very difficult to quantify or allow for
- Framing issues in what to communicate
- Again often ask for:

  (expert judgement $\otimes$ model)

The Textbook Problem: how to report



Group of experts



Cooke's Principles

- **Empirical control:** Quantitative expert assessments are subjected to empirical
- **Neutrality:** The method for elicitation, analysis and combination should encourage experts to state their true opinions, and must not bias results.
- **Fairness:** Experts are not pre-judged, prior to processing the results of their assessments.
- **Scrutability/accountability:** All data, including experts' names and assessments, and all processing tools are open to peer

Experts are prejudged.
They are accepted as expert.

Few reports satisfy this.
Chatham House reporting

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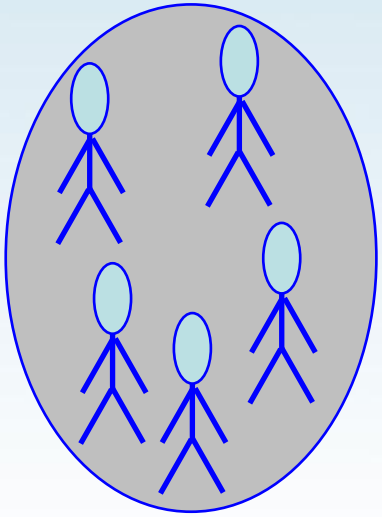
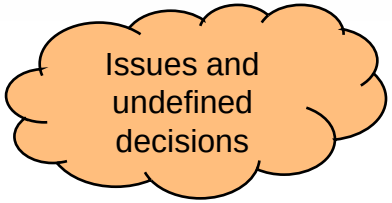
The Textbook Problem



Group of experts



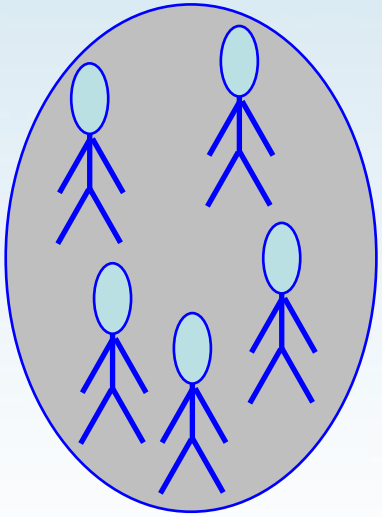
- Exploring issues, formulating decision problems, developing prior distributions
- Since the precise decision problem is not known at the time of the expert studies, the reports will be used to build the prior distributions not update them
- So report should anticipate meta-analyses

The Textbook Problem

Meta-Analysis

- Goes back to Karl Pearson
- Glass (1976) brought into statistical mainstream
- Cochrane Collaboration and Evidence-Based Medicine
- Focused on systematic review of empirical studies
- Regression/linear model based

The Textbook Problem

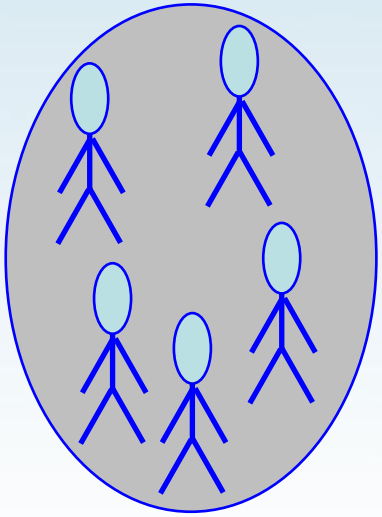


Group of experts

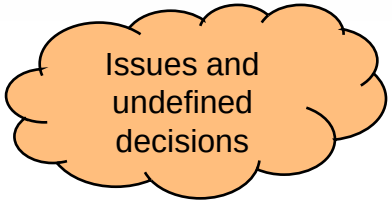
Issues and undefined decisions

- Exploring issues, formulating decision problems, developing prior distributions
- Since the precise decision problem is not known at the time of the expert studies, the reports will be used to build the prior distributions not update them
- So report should anticipate meta-analyses
  - Report individual judgements
  - Provide calibration data, expert biographies, background information, etc.

The Textbook Problem



Group of experts



Need meta-analytic approaches for expert judgement

- Little peer-review
- Less publication bias, but more context bias
- ‘self’ promotion’ of reports by pressure groups
- Cooke’s principles seldom considered
- Independent experiments vs correlated experts
- Experimental Design vs Elicitation Protocol

So where does this leave us?

We need to consider:

- reporting standards for expert judgement studies that allows them to be audited and evaluated;
- meta-analytic methodologies for expert judgement data.

Reporting and Archiving

- Cooke's four principles, we need to discuss, augment, agree and implement them.
- We cannot change what happens across the web, but we can create well managed archives.
  - TU Delft database
- Establish peer review procedures

More details

Simon French (2011)

AGGREGATING EXPERT JUDGEMENT

Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales. Serie A. Matematicas **105**(1),181–206

Simon French (2012)

EXPERT JUDGEMENT, META-ANALYSIS AND PARTICIPATORY RISK ANALYSIS

Decison Analysis **9**(2): 119-127 .

Thank you