

CRC Association, May 2018

Decisions under Uncertainty: Would you rather be vaguely right or precisely wrong?

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Outline

- Decisions, uncertainty and outcome (business) performance
- Expert judgements and uncertainty assessments
- Key Messages

A large part of how your (or your organization's) life unfolds is a result of your decisions - this is all you can control !

The rest depends upon things you cannot control: the decisions of others, "nature", chance,

Why is this important: Reported or Overheard

- Oil & Gas super-major:
 - “Every one of our 10 most important projects failed to generate the desired return.”
- Large independent:
 - “The actual outcomes of key assets weren’t even in the P_1 to P_{99} range.”
- CEO to manager:
 - “I want your guarantee that we will not spend more than the P_{50} ”!
- Booz Allen Hamilton Report (2006):
 - “more than half of the executives said they are dissatisfied with their companies’ overall project performance, citing the costly budget and schedule overruns that plague 40 percent of their projects.”
- Ernst & Young:
 - “62% average cost overrun for mining mega-projects”

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Independent Project Analysis (IPA):

- 1 in 8 major projects are ‘disasters’.
- 1 in 2 in two mega-projects (CapEx > \$1billion) are ‘disasters’

“The bigger and more important a project gets, the more likely it ends up in the ‘disaster’ category.”

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What's the problem 1 ?

Decision outcomes not living up to expectations or possibilities



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What's the problem 1 ?

Decision outcomes not living up to expectations or possibilities

- People tend to grossly under-estimate uncertainty
 - number of uncertain factors
 - the magnitude of uncertainty and its consequences (good or bad)
- Better decision-making requires *accurate* (= unbiased, appropriate range) uncertainty assessment
- Mis-understanding or mis-application of NPV “rule”
 - Uncertainty (and/or delay) => Value Loss.

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What's the problem 2 ?

Decision outcomes not living up to expectations or possibilities



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What's the problem 2 ?

Decision outcomes not living up to expectations or possibilities

- Many best predictions, judgments or decisions are **non-intuitive**, especially when uncertainty and complexity are present
 - in such situations, most of us fall prey to systematic biases that result from mental short-cuts (heuristics)
- Example: when forecasting the outcomes of risky projects, decision-makers easily fall victim to the Planning Fallacy.
 - they spin scenarios of success while overlooking the potential for biases, mistakes and miscalculations.
 - as a result, decision-makers pursue initiatives that are **unlikely** to come in on budget or on time – and so unlikely to deliver the expected returns.

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Decision-making is about ranking: Single-point estimates of decision metric

● Single-point Estimates/Predictions

Max
Possible Outcomes
Min
Chance

Uncertainty in decision **Objective**
eg NPV, Volume, ...

A B C D

In the absence of an assessment of the uncertainty,
worse than useless?

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Decision-making is about ranking, based on “decision value”, not best prediction! Case 1: Trivial

Here, B is clearly the best choice

Uncertainty in decision **Objective**
eg NPV, Volume, ...

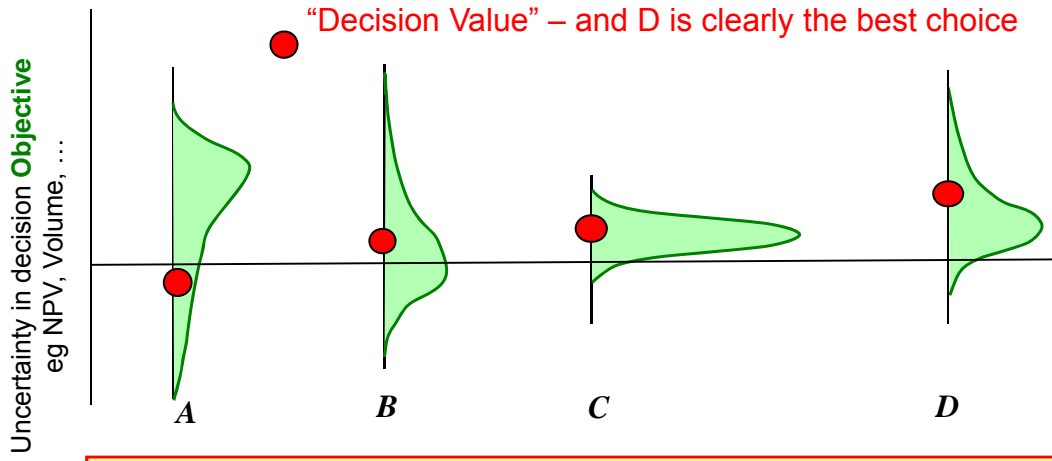
A B C D

Alternatives (choices)

We only need to predict objective outcomes precisely enough
to determine which is the best alternative

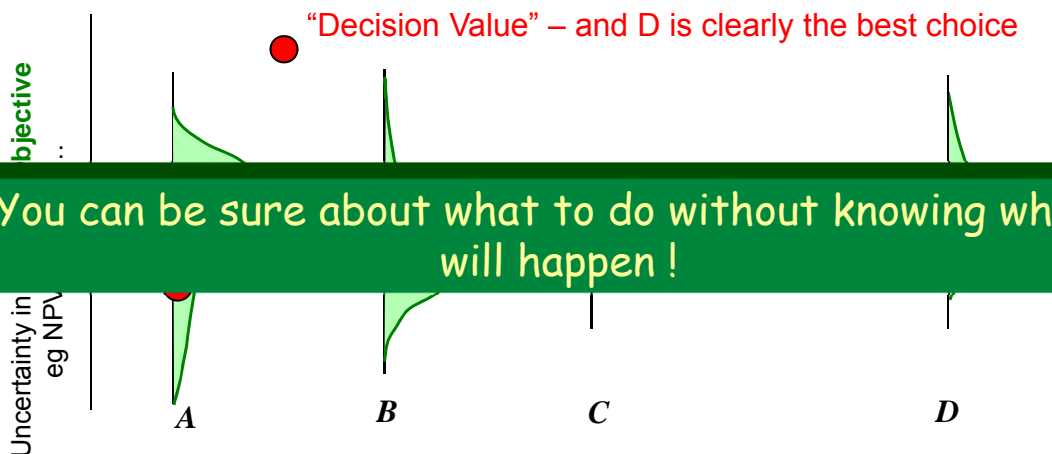
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Decision-making is about ranking. Case 2: We need a "decision value" to compare the uncertain situations



Whatever number we use for the decision value, it will depend on the possible outcomes and their chance of occurring (probability)

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Technical Work in the context of Decisions and Uncertainty: Knowing when enough is enough.

The main role of most “technical” jobs (geologist, engineer, physicist, doctor, economist, market analyst) is to support decision-making

- Technical work (data gathering, modelling, analysis.....) is fundamentally about uncertainty assessment for the purpose of making decisions
 - **First priority:** Accurate (=unbiased) uncertainty assessment
 - **Second priority:** Uncertainty reduction if economically justified
- But if you have a “make the best possible prediction” focus, there is no stopping rule
 - you can always reduce uncertainty a bit more (more data, more time, more detail, more accurate physics/geology/tax, more analysis, ...)
- A decision-driven (ranking) focus gives a trivially simple stopping rule
 - Stop when further analysis **doesn't change the decision!!**

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Why is this important? We spend a lot of money without really knowing which uncertainties matter











<u>Parameter</u>	<u>Uncertainty</u>	<u>Impact on Value</u>	<u>Possible Actions</u>
Recovery Efficiency			Finer-scale models
Copper Price			Hedge with futures
Hole Cost			Research on drilling
Average thickness			More drill holes
Grade			More Assays
Strike length			More drill holes
Spatial Continuity			More drill holes
Contractual Terms			Fire lawyers

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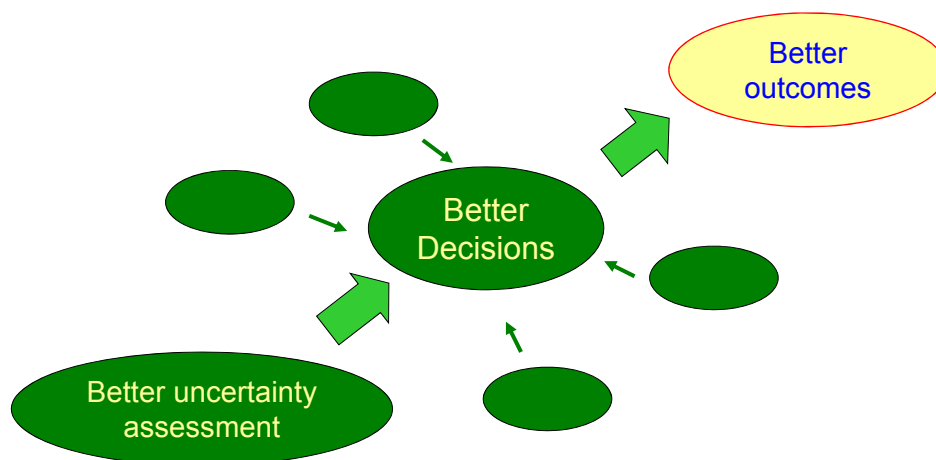
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"There is nothing so inefficient as very efficiently doing the wrong things".

Peter Drucker

The fundamental problem & solution?

Flawed Decision-making



Outline

- Decisions, uncertainty and outcome performance
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Assessment of Expertise

- Compared to your peers (the people in this room), on a scale of 1 to 10, where
 - 1 is poor
 - 5 is **average**
 - 10 is very goodhow good a **driver** are you?
how good is your **intuition**?
how good a **decision-maker** are you?
- 82% of people say they are in the top 30% of safe drivers;
- 86% of MBA students say they are better looking than their classmates;
- 81% of new business owners (= CRC CEOs?) think their business has at least 70% chance of success, but only 39% think that a business just like theirs is likely to succeed.

Assessment of Expertise

- Compared to your peers (the people in this room), on a scale of 1 to 10, where
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how good a **driver** are you?
 how good is your **intuition**?
 how good a **decision-maker** are you?

When assessing their position in a distribution of peers on almost any positive trait, 90% of people say they are in the top half.

Steel Band Problem

- Assume the earth is perfectly spherical and a band of steel is placed around the equator, which has a circumference of 50,000 km.
- Now we add in an extra 10m of steel, which slightly forces the band off the surface of the earth.
- What is your intuitive estimate of how much?
 -
 - The diameter of a proton, an atom ...
 - Thickness of a \$ note
 -

This is an example with no uncertainty, slight complexity

Developing valid beliefs in relationships between actions and outcomes

- Feverfew (a herbal medicine) is thought to be effective in treating headaches. Suppose 25 unbiased observations have been made as shown below. Does this data support the claim?

		Headache	
		Went	Stayed
Feverfew	Took it	16	4
	Didn't	4	1

- Compare frequency of headache going whether Feverfew is taken or not

Headache **went away** when Feverfew **was taken** = $16/20 = 80\%$

Headache **went away** when Feverfew **was not taken** = $4/5 = 80\%$

- Conclusion: taking Feverfew has no effect!

This is an example with slight uncertainty, no complexity

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Developing valid beliefs in relationships between actions and outcomes

- Feverfew (a herbal medicine) is thought to be effective in treating headaches. Suppose 25 unbiased observations have been made as shown below. Does this data support the claim?

		Headache		
		Went	Stayed	Total
Feverfew	Took it	16	4	20
	Didn't	4	1	5
Total		20	5	25

If you use observations to develop beliefs you need (unbiased) observations in all 4 boxes!

– don't draw conclusions based on just the number of positive occurrences

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Reliability of Predictors:

- Analysis suggests about one in every 1000 car airbags have serious flaws.
- Suppose x-ray analysis is a very good, but not perfect, detector of these flaws.
 - If an airbag has flaws, x-rays will correctly say it has them 99% of the time
 - If an airbag does not have flaws, x-rays will correctly say that it does not have them 98% of the time
- An airbag has been chosen at random to be x-rayed and the result was positive!
 - What is your **intuitive assessment** of the chance that it has flaws?

_____ ? _____ %

This is an example with some uncertainty and complexity

Reliability of Predictors:

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- An airbag has been chosen at random to be x-rayed and the result was positive!
 - What is your intuitive assessment of the chance that it has flaws?

4.7%!

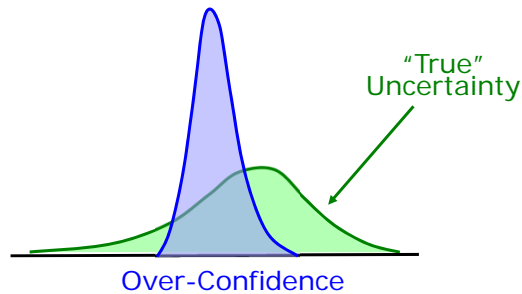
P(Test Positive given Flaws) = 99%

P(Flaws given Test Positive) = 4.7%

This is an example with some uncertainty and complexity

Overconfidence

- Assigning a much narrower PDF than is warranted by our true state of information about the quantity of interest
 - driven by being **unaware of the limits of our knowledge**
 - we often think in terms of how much we know versus how much we don't know



- Overconfidence can lead decision-makers to under-invest in
- collecting more information to narrow the range
 - designing-in flexibility to mitigate downside or capture upside

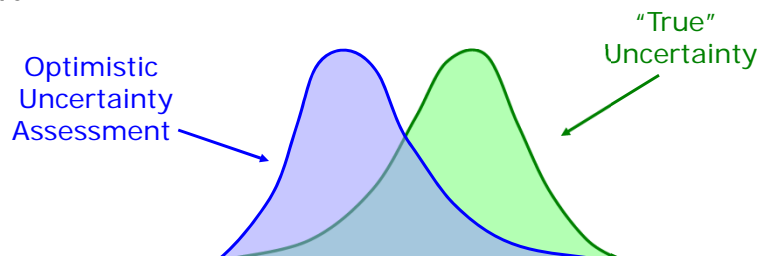
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Optimism

- **Confusing preference with chance:** Assigning
 - higher probabilities to more-preferred outcomes
 - lower probabilities to less-preferred outcomes
 than objective criteria, experience, data or logic warrants.
 - can be a motivational (rather than cognitive) bias e.g. an incentive to be optimistic rather than realistic



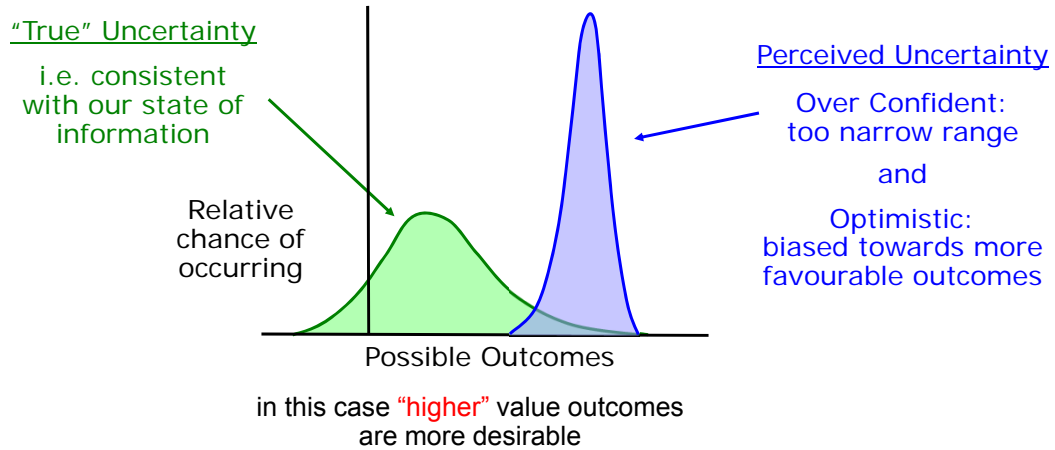
- The more optimistic the forecasts, the more likely a project is to be chosen
– and less likely to deliver!

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Overconfidence & Optimism – probably the most common situation!



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Anchoring Question: Oil & Gas Industry Expert Results

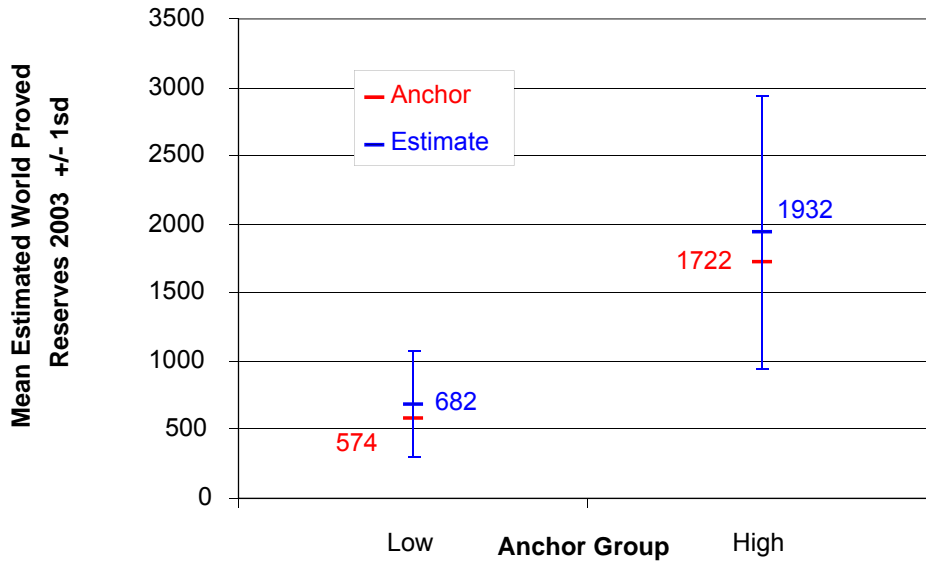
- Alternate versions of a simple yes/no question, with high and low anchors, were given to two groups
 - **High Anchor Group:** "Were world proved oil reserves in 2003 greater or less than 1721.6 Billion Barrels?" Y or N
 - **Low Anchor Group:** "Were world proved oil reserves in 2003 greater or less than 573.9 Billion Barrels?" Y or N
- Both groups then asked the same question
 - "What is your best estimate of the world proved oil reserves in 2003?"

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Anchoring Question: Oil & Gas Industry Expert Results

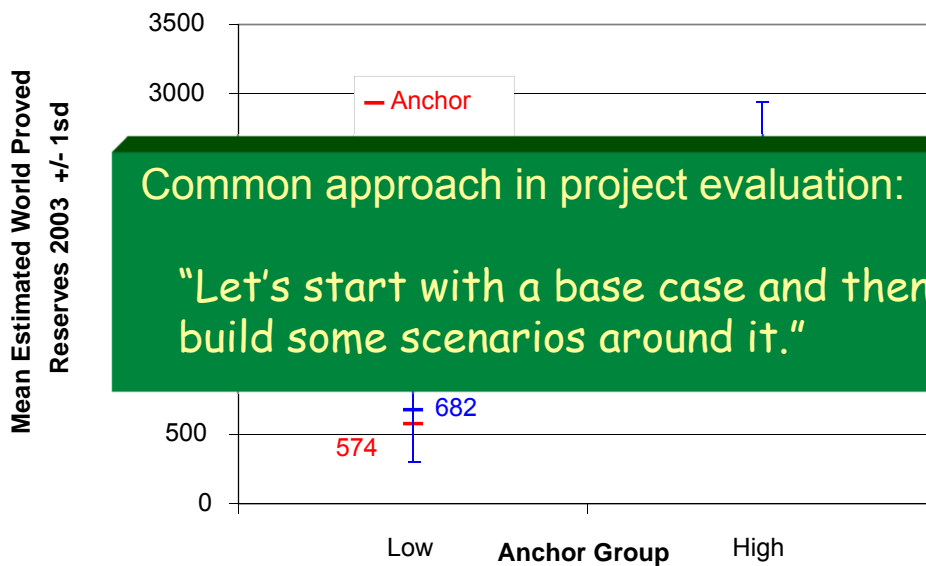


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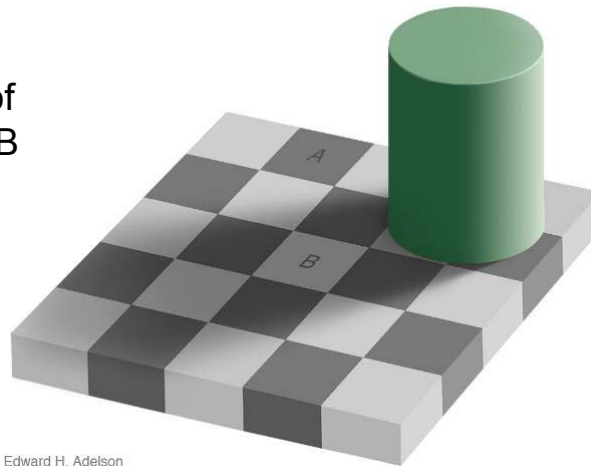
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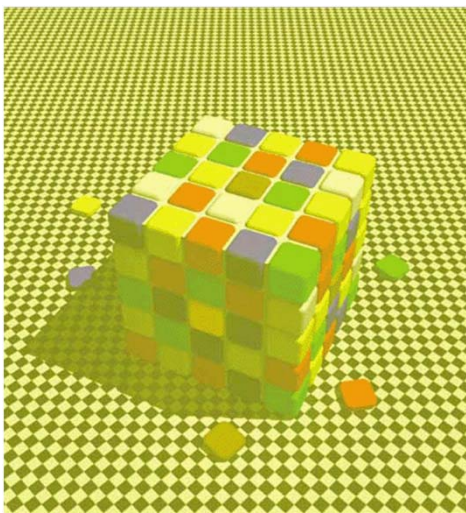
Estimate the gray %

Using a scale of
black = 0%
white = 100%
what is your visual estimate of
the % gray of squares A and B



Edward H. Adelson

Blue and Yellow tiles in Rubik's Cube



Illusion by Beau Lotto

Visual illusions are a metaphor for cognitive illusions

- Folk Wisdom states: Seeing is Believing
 - People are **convinced** of the validity of their own sensory experience (and **intuitions, thought processes** and **memories**)
- Psychological research disagrees: people are subject to many illusions which cause them to
 - see things that are not there,
 - believe things that are not true,
 - reason incorrectly and
 - remember incorrectly
- Visual illusions are to reality, what fallacies are to reasoning

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Visual illusions are a metaphor for cognitive illusions

- Folk Wisdom states: Seeing is Believing
 - People are **convinced** of the validity of their own sensory experience (and **intuitions, thought processes** and **memories**)

- Awareness of illusions, by itself, does not necessarily lead to a correct perception.
- Like visual illusions, fallacious beliefs and/or reasoning can remain compelling and thus extremely difficult to overcome.

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What Does This Have to Do With You and Me?

- Evidence shows that oil & gas professionals are as prone to these biases and illusions as anyone else. Why would other professionals, managers or researchers, be different?
- Some common biases and traps in decision-making
 - Confusing Uncertainty with Variability and risk
 - Intuition about Chance
 - Positive Illusions (Superiority)
 - Availability and Vividness
 - Overconfidence
 - Optimism
 - Unintended risk attitudes
 - Anchoring
 - Confusing typicality (representivity) with chance
 - Illusion of Control
 - Base Rate Neglect
 - The confirmation trap
 - Hindsight Foresight and the "curse of knowledge"
 - Knowing when enough is enough
 - The Law of Small Numbers

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What Does This Have to Do With You and Me?

- Evidence shows that oil & gas professionals are as prone to these biases and illusions as anyone else. Why would other professionals, managers or researchers, be different?

Human beings are not naturally-endowed with rational thinking under uncertainty.

- Intuition about Chance
- Positive Illusions (Superiority)
- Illusion of Control
- Base Rate Neglect
- The confirmation trap



Bias / error leads to:
=> unwarranted beliefs poor judgements
=> poor decisions
=> undesirable outcomes

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Key Messages

- In the presence of uncertainty, precise single-value (deterministic) predictions are almost useless, perhaps worse
 - to make decisions we need to know all the possible outcomes and their chance of occurrence (be vaguely right)
 - rank options based on “decision value” value, not the best (precisely wrong) prediction
- Evolution has not “wired” our brains for a good natural ability to assess uncertainty, or to reason correctly in complex, uncertain situations
 - the resulting biases (systematic errors of thought, evaluation), not uncertainty *per se*, is a cause of poor outcomes
 - develop a healthy skepticism for the reliability of our intuition
 - technical expertise is no protection (unless it includes bias avoidance)
- The only way to better outcomes is by making better decisions
 - adopt the principles of Decision Quality and implement through the structured tools and methodology of Decision Analysis

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Acknowledgements

- Matthew Welsh, University of Adelaide
- Reidar Bratvold, University of Stavanger
- Michael Lee, University of California, Irvine

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