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Oiling the Cogs: how Cognitive Science can improve Oil Industry Decisions

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Society of Petroleum Engineers Distinguished Lecturer Program
www.spe.org/dl
• The Problem
  – Actual performance ≠ Predicted performance
  – We can’t seem to fix this

• The Solution (part 1)
  – Understanding WHY the problem occurs
  – Spoiler: it’s our cognitive processes

• The Solution (part 2)
  – Implications for HOW to fix it
The Problem(s)

• Large projects consistently underperform
  – E.g., 46% cost & 28% time overruns (Merrow, 2003)

• Predictions of production
  – Can be overly optimistic
  – Are overconfident
  – Etc....

• I.e., cognitive biases affect judgments

Overconfidence

<table>
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<th></th>
<th># Forecasts</th>
<th>Expected</th>
<th>Observed</th>
<th>Calibration</th>
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<td>56</td>
<td>44.8</td>
<td>33</td>
<td>58.9%</td>
</tr>
<tr>
<td>NGL</td>
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<td>37.5%</td>
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<tr>
<td>LNG</td>
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<td>44.8</td>
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</table>

- Recent data showing monthly production forecasts
- Showing marked ‘overconfidence’
  - P10-P90 forecasts should contain 80% of actuals
- Capen (1976) raised this 40+ years ago
  - Why no progress?

Overconfidence

• Awareness does NOT prevent overconfidence

• People resist reducing their range widths
  – Argue: “wide ranges are uninformative”
  – E.g.
    • A) Mt Everest is between 7 and 8 km high
    • B) Mt Everest is between 5 and 15 km high
  – People prefer ‘A’ even after learning it is wrong

Cognition vs Rationality

• Human reasoning is:
  – Not strictly rational
  – Deeply ingrained
  – Ill-suited for probabilistic thinking
  – Designed to limit cognitive effort

• Pointing out their errors
  – Does not change their approach
  – Or demonstrate what they should do

• Acting rationally is unnatural
Where to now?

• Understand HOW people think

• Contrast this with their tasks

• To understand WHY biases occur

• And see whether they can be avoided
A Starting Point

• Heuristics and Biases literature lists 30+ individual biases
  – See, e.g., Kahneman (2011)

• Rather than picking example biases....

• Start with core, cognitive processes
  – Causes of reasoning biases
  – Resistant to changes

Memory Processes

• How we think memory works

• How memory actually works

• Biases result from normal memory function
Video-camera of the Mind

- Belief everything we see/hear is recorded

- Common view of memory
  - Underlies faith in eye-witnesses
  - And acceptance of repressed memories
  - Both are disputed by researchers
    - E.g., Elizabeth Loftus

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Memory Test
Memory Test
What changed?
Change Blindness

• People don’t notice these changes

• Because they DON’T have the picture stored in their heads

• Rather, they store details:
  – The sky is blue
  – There is a large plane
  – Soldiers are boarding it

• Then check for these same ‘details’
Forgetting

• Non-essential details are quickly forgotten

• As are older events
  – What did you have for breakfast today?
  – What did you have for breakfast 1 year ago today?

• This is adaptive in most environments
  – Yesterday’s events are more important than more distant ones.
Remember when...?

• Recall your last holiday?
• Where did you go?
• What did you do?
• Picture the location?
• Think of a specific activity
• Do you have an image of yourself engaged in that activity?
Point of View

• In the memory you have just recalled, can you ‘see’ yourself?
Lego of the Mind

• Memory is more like Lego than photos
  – We reconstruct memories from pieces of data
  – Substituting pieces that weren’t there is easy
Memory-based Effects

- Hindsight Bias
- Availability
- The Wisdom of Individuals
Hindsight Bias

• People judged prior likelihoods for outcomes of Richard Nixon’s trips to Beijing & Moscow.

• Asked to recall these months afterward
  – Events that DID happen, they believed they had rated more likely
  – I.e., They “knew it all along”

Oil Industry Hindsight

• A key industry task is predicting the future
  – Oil prices, production values, etc
  – Extremely complex

• When the future is resolved
  – We have ’20/20 hindsight’
  – Constructing a causal explanation
  – becomes simple

• We project that back in time
  – altering our memory of what we believed
Hindsight Bias Knock-Ons

• Record keeping should prevent hindsight bias
  – Written predictions can’t be easily updated

• If it doesn’t...

• Hindsight Bias => overconfidence
  – Confidence should = competence
  – But hindsight bias makes us think we were right more often
  => Overestimating how often we will be right in future
Availability

• Cognitive process used to judge likelihood
  – How many events can I recall?
  – I.e., are ‘available’ to memory?

• Good approximation for natural environs but....
  – We don’t live in a natural environment
  – Memory doesn’t treat events equally
    • Recent events are more memorable
    • As are surprising/emotional events
    • Context affects memory availability

Unpacking

• Availability contributes to the Planning Fallacy (underestimation of times and costs)
  – Because HOW we ask for estimates changes what we recall

Welsh et al (2010)

± 200 hr

Unpacking

• Packed = ‘All associated problems’

• Unpacked = ‘Mud conditioning, well control operations, fishing operations, severe weather, rig repairs, logistic delays & all associated problems’

• Logically, Packed = Unpacked
  – Packed = 66hrs
  – Unpacked = 267hrs
  – Actual = 400hrs
Wisdom of Individuals

• Wisdom of Crowds
  – Averaging multiple estimates is more accurate than using one individual’s

• Results from
  – Different people knowing different things, and
  – Errors being random and averaging out

Role of Memory Limits

• Memory is a constructive process

• Working memory is limited (~7 items)

• Each estimate can draw a different subset – biased in different ways

• Repeated estimates => Wisdom of Crowds-style benefit

Cognitive Psychology

• Describes how people think

• Explains why people display biases

• Shows which biases are avoidable

• Tells us HOW to avoid bias
Example: Reducing Overconfidence

• Confidence >> Knowledge because...
  – Prefer informativeness over accuracy
  – Limited cognitive effort
  – Failure to consider enough alternatives
  – Effect of hindsight bias

• => Resist direct attempts to change estimation

• How to get better calibrated estimates?
Better Elicitation

- More-Or-Less Elicitation (MOLE)

- Underlying psychology
  - Better at relative than absolute judgments
  - Repeated estimates are better than single ones
  - People focus too much on best estimates

MOLE Process

- Start with very wide range
- Randomly select pair of possible values
- Which is closer to the ‘true’ value?
- How confident are you?
- Update possible range based on response
- Repeat for $2^{nd}$, $3^{rd}$, etc pairs of values
- Combine set of judgments into final estimate
How does this help?

• Random selection from wide range
  – Prevents focus on best estimate
  – Forces consideration of wide range of possibilities

• Choice between given options
  – Allows relative rather than absolute judgments

• Repeated judgments
  – Circumvent memory limitations
  – Multiplies cognitive resources
  – Without repetition
MOLE Advantages

- No specialised knowledge required
  - I.e., benefit of MOLE occurs without understanding why

- Range reduced from the outside in
  - Tends to include more feasible values
MOLE Results

• Forecasting Task
  – Oil and gas prices, O&G share prices, etc
  – MOLE vs direct estimation of range

Conclusions

• Our cognition is suited for particular environments
  – Biases are mismatches between cognition and rational expectations

• Cognitive science helps us:
  – understand when and why people show biases
  – design elicitation processes that work with cognition

• => Improved estimates and decisions.
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