



Primary funding is provided by

**The SPE Foundation through member donations
and a contribution from Offshore Europe**

The Society is grateful to those companies that allow their
professionals to serve as lecturers

Additional support provided by AIME



Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

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

Dr Matthew Welsh



THE UNIVERSITY
of ADELAIDE



Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Outline



- The Problem
 - Actual performance \neq 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



	# Forecasts	# Inside P10-P90 Range		Calibration
		Expected	Observed	
Oil	56	44.8	33	58.9%
NGL	56	44.8	21	37.5%
LNG	56	44.8	23	41.1%

- 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



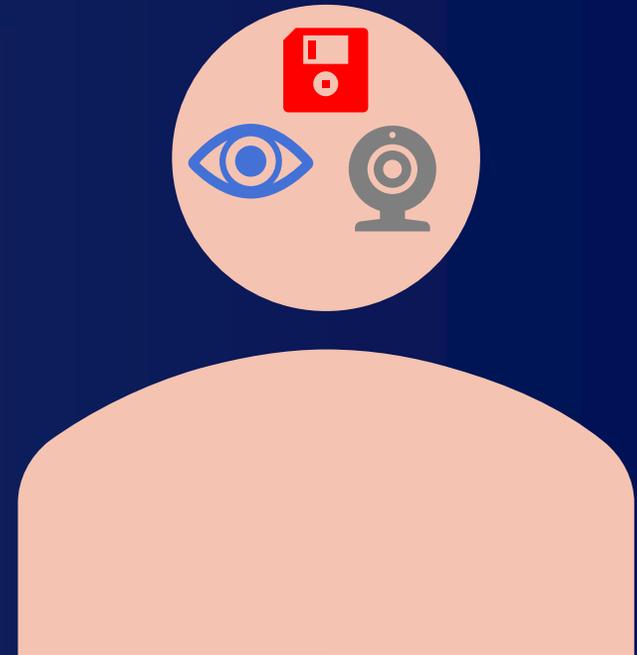
- How memory actually works



- 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



Loftus, E., & Ketcham, K. (1996). *The myth of repressed memory: False memories and allegations of sexual abuse*. Macmillan

Loftus, E. F., Doyle, J. M., & Dysart, J. E. (1997). *Eyewitness testimony: Civil and criminal*. Lexis Law Pub..

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'

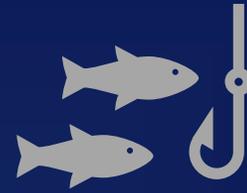
Forgetting



- 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

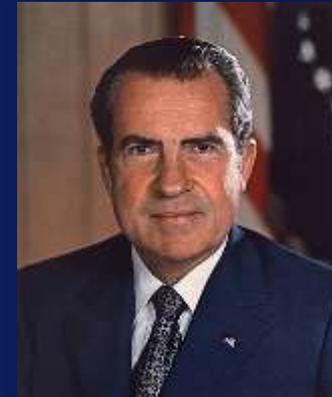


- Hindsight Bias
- Availability
- The Wisdom of Individuals

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

H

IN

DSI

GHTI

S2020

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

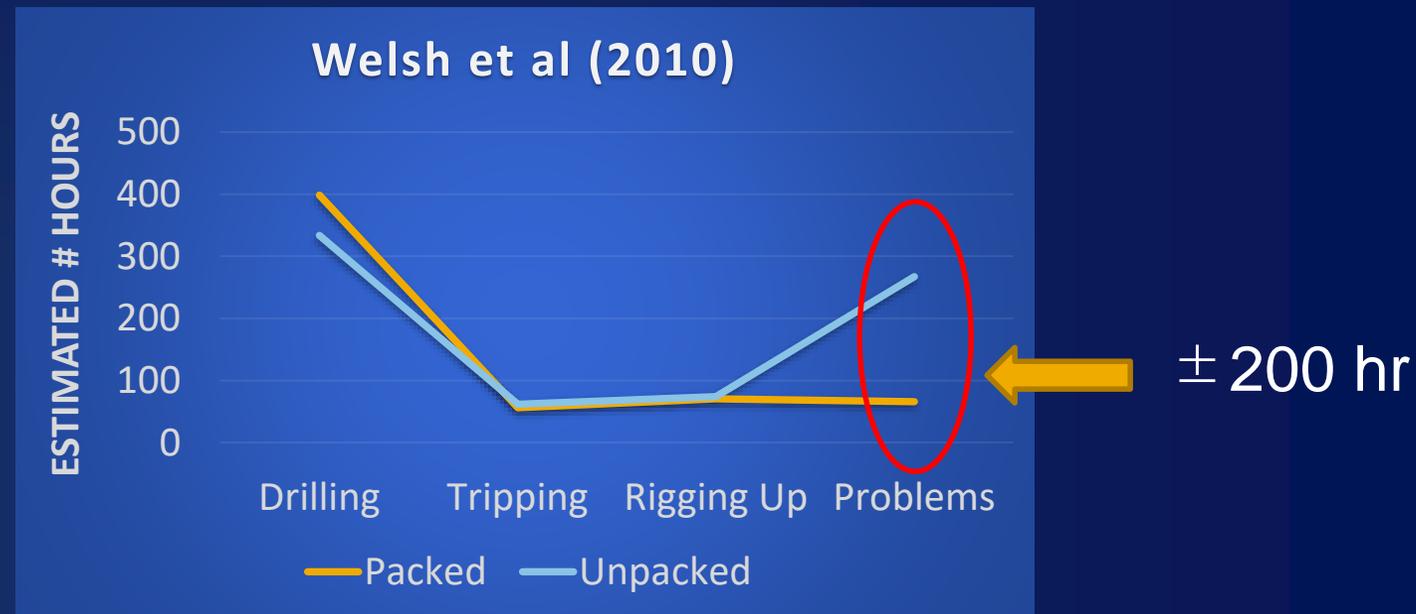
Availability

- 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



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

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological review*, 63(2), 81.

Vul, E., & Pashler, H. (2008). Measuring the crowd within: Probabilistic representations within individuals. *Psychological Science*, 19(7), 645-647

Herzog, S. M., & Hertwig, R. (2009). The wisdom of many in one mind: Improving individual judgments with dialectical bootstrapping. *Psychological Science*, 20(2), 231-237.

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 2nd, 3rd, 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

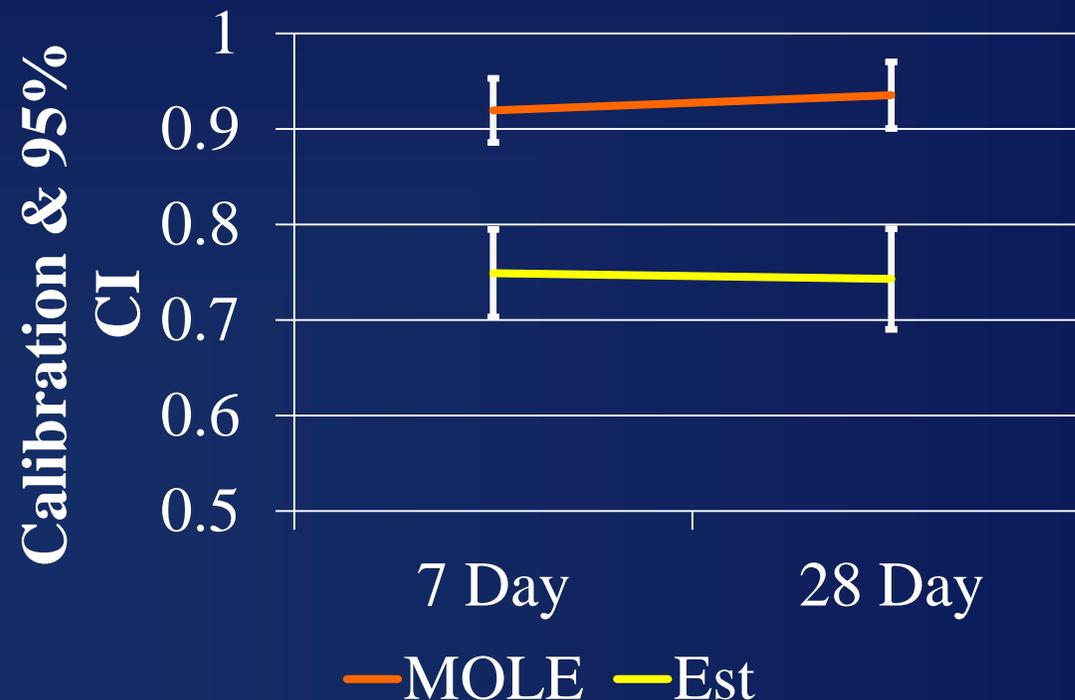
- No specialised knowledge required
 - I.e., benefit of MOLE occurs without understanding why
- Range reduced from the outside in
 - Tends to include more feasible values



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.



Thank you

Your Feedback is Important

Enter your section in the DL Evaluation Contest by
completing the evaluation form for this presentation

Visit [SPE.org/dl](https://www.spe.org/dl)

[#SPEdl](https://twitter.com/SPEdl)



Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

