UNDERSTAND AND OVERCOME BIAS

#1 Introduction

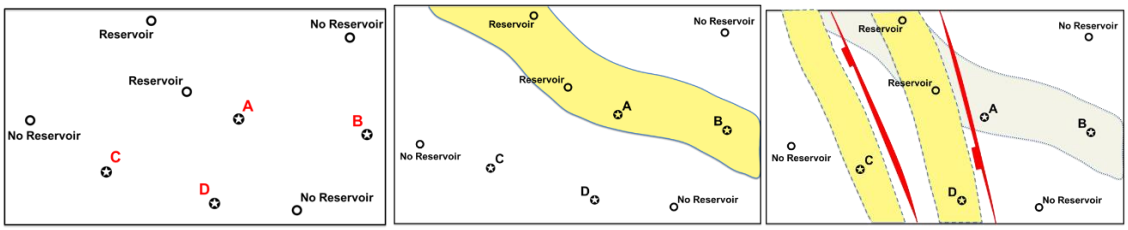
WELCOME!

Hello and welcome to my blog on the topic of Bias!

WHAT IT IS (AND ISN'T) …

Upfront, we will not be talking about some important biases that have received a lot of media attention lately, such as *implicit bias* (an unconsciously-held set of associations about a social group, commonly known as a 'stereotype'). Rather, as a geoscientist, I will focus on the biases that affect our decisions and interpretations in the petroleum exploration and production business.

Let's take a look at an example of how these biases could manifest themselves in our industry. Say you have some wells labelled 'Reservoir' and 'No Reservoir' as noted on the map below on left, and you have developed a model of a NW-SE trending channel as shown on the map in the middle. You can purchase two wells (sorry, your boss has limited funds!) to further your interpretation - which two wells would you purchase? Your inclination would perhaps be to purchase wells A and B. But what if the correct model was the map on the right? By purchasing wells A and B you would be none the wiser. This is an example of *confirmation bias*, which we will explore in upcoming posts.



What can we do when we recognise this bias?

… AND WHY IT IS IMPORTANT

Why is bias so important to understand? Let's start by looking at my career journey and what I have discovered.

I began my career 40 years ago in the USA, working onshore oil projects as an exploration geophysicist. I have since worked on projects on every continent (except Antarctica). As a team leader, exploration manager, assurance manager, and finally chief geophysicist, I have been able to see many different projects and evaluations done by others.

My years as Head of Subsurface Assurance, were key in deepening my interest and understanding of biases. With my colleagues, we reviewed and assured thousands of projects. Our goal was to provide objective, independent and consistent guidance to teams and management about their assessment, recommendations and decisions. What we observed was that the teams were making *predictable*, *consistent* and *repeatable* errors in their interpretations and decisions.

Now, working as a consultant with Rose & Associates, I am observing similar patterns within other companies. In other words, cognitive bias is endemic within the industry, and unfortunately these biases can lead to poor predictions and decisions, and in the end, loss of value.

SO WHY IS IT RELEVANT?

Ok, so our success rate as an industry is not where we would like it to be. Could it be poor technical expertise? Poor decision-making processes? Lack of training? I suppose for some companies and individuals this could be true, but for the vast majority of us, this is not the case. So, what else could it be? Asking this question led me to research cognitive biases and learn about their impacts on us.

My experience led me to develop, along with my colleague Creties Jenkins, a training course entitled **Mitigating Bias, Blindness and Illusion in E&P Decision Making**. We both thought it was important topic to help people mitigate these biases, but we were not sure if the industry would welcome such a course. Well, we must have hit a nerve! Over the past four years, we have delivered this course nearly 100 times! Clearly, people in the industry see bias as an important issue that can negatively impact their work and are looking for strategies to mitigate them.

In my blog, I will share interesting and relevant topics on bias and how they relate to our industry. I will discuss several of the important biases, but I also hope to delve deeper into the topic of bias. Some of the material will come from the course, but I will also explore many other areas related to bias. My hope is that this will be an engaging and collaborative forum for us to express our ideas; and I welcome comments, questions and most importantly, examples where you have observed bias in your work and perhaps tried to mitigate against it. My intention for this blog will be to post every few weeks.

Until the next time, stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#2 Cognitive Bias

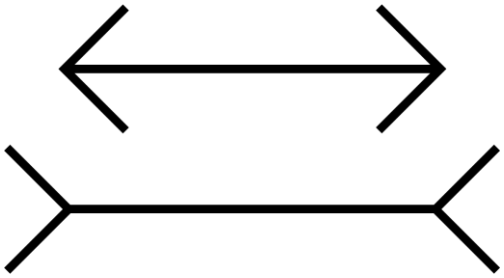
COGNITIVE BIAS

What is a cognitive bias? You will have heard the term bias; the word can have a negative connotation as it can denote prejudice against others. Further, you might even dismiss the idea when I say these biases are normal and we all have them.

Simply put, cognitive biases are *predictable*, *consistent*, and *repeatable* mental errors in our thinking and processing of information that can lead to illogical or irrational judgments or decisions. Note a key word here - "can". Cognitive biases do not necessarily lead to poor or irrational decisions. I wrote about this concept in my blog article on the Rose & Associates platform.

LET'S SEE HOW THEY MAY WORK

I like to use this famous optical illusion to help us understand how these cognitive biases work in our thinking. You have all seen this one before ….. which line is longer?



What is so infuriating about this figure is that we know the answer but cannot see it. Most of us will believe the lower image line length is longer, but in fact they are the same (if you don't believe me, measure the lines). So, I know you will believe the lower line is longer (*predictable*), you will always think that (*consistent*), and no matter how many times you see this figure you will have the same answer (*repeatable*).

Cognitive biases work similarly to this example. The difference is that where the line length judgment is a mistake that can be rectified by measuring the lines, a cognitive bias is an unconscious mental error in our processing of information that can lead to poor decisions.

WHY? REFLEXIVE VS REFLECTIVE THINKING

One reason this occurs is that when we think about things and make decisions, we tend to react "reflexively"; in other words, we use intuition, instinct, and sometimes emotion. Our reaction tends to be automatic and quick, taking little time and mental effort.

Let's take a look at a great example from *Thinking, Fast and Slow* by Daniel Kahneman (Penguin Books, 2011). What visual image comes to mind when you read the following:

Ann approached the bank

If you are like most of us, you would have thought about money, a building, a loan; and if you wanted to find out more about Ann, you would be asking questions related to these ideas. Yet, what if Ann was in a boat? Clearly your questions would probably not provide any knowledge about Ann! That's reflexive thinking. Instead, what we need to do is to think "reflectively", which invokes critical, deductive, rational, and logical thinking.

Unfortunately, that is not how our brains work. Reflexive thinking is the automatic and unconscious response that comes first; we actually have to work at thinking reflectively. This example shows the need to consider alternative scenarios when making judgments.

BIAS, BIAS EVERYWHERE

There are hundreds of biases, but the goal in this blog is to focus on the biases that influence our evaluations, behaviours and decision-making. For a listing of different biases, see Wikipedia List of Cognitive Biases.

So, let's play a little game to show you how biases can influence your judgments. In ten seconds, count how many words in the English language you can think of that start with the letter K. Ready, go …….

Ok; well done. Now, let's try that again. In 10 seconds count how many words in the English language you can think of where K is the fourth letter. Ready, go ……

If you are like most English-speaking people, you probably came up with lots of words that started with K; but the fourth letter? Perhaps none! Which of the two is more likely, words that start with the letter K or have K as the fourth letter? It turns out that there are about 50% more words where K is the fourth letter! What's going on? This is known as the *availability* bias (also known as the *recency bias*). It reflects our tendency to overestimate the likelihood of events that are easier to recall. Since we were using quick reflexive thinking, it was a lot easier to think of words starting with the letter K so we assumed there are more of them!

SO WHAT?

Ok; hopefully you found that interesting, but so what? Well, imagine you are working up a new geologic play and you note that there have been some successful wells; this might make you feel more optimistic about the play. Or the inverse, lots of dry holes have been drilled recently may lead you to underestimate the play potential. What can we do to mitigate the *availability* bias? One strategy is that we could search out statistics and provide examples to support other possibilities rather than relying just on our intuition or experience.

MITIGATING BIAS

These biases are normal. We all have them. And in a lot of situations they are helpful and lead us to a satisfactory solution. We are not "bad people" because we have them; and in fact, they are essential to human functioning and we wouldn't be here if we didn't have them (*teaser alert: we will explore this in a later blog article*). So yes, these biases are normal and helpful in many situations; but unfortunately, they can also lead us to poor judgments and decisions.

Although a good first step, awareness alone does not alleviate their influence as shown by the line length example. Studies have shown that there is little to no correlation between intelligence and susceptibility to bias nor any specific traits that protect an individual from being biased. Rather, we must recognize these biases and when they may be negatively influencing us, and then learn techniques to mitigate their impact.

In the future we will explore other topics related to the nature of bias as well as discussing several important ones such as *anchoring, confirmation, framing, information, overconfidence*, and *motivational*. We will see how they impact us and how to mitigate their influences.

For the next post, we will discuss the *information* bias, where we have a tendency to have a distorted perception of information and its significance.

Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#3 Information, part 1

UNDERSTANDING AND OVERCOMING BIAS

I have found with my work and research about bias that I now notice them continually in not only my consulting, but just in everyday life. For example, last year I was teaching R&A's Mitigating Bias course for a client and coincidently while I was at breakfast, I picked up the paper and ran across an article on vaccines and some people's reticence about immunizing themselves or their children.

Interestingly, much of the article talked about the various cognitive biases we have, and how they impact our decisions. There were several that were mentioned, but one I want to talk about in this blog is how people struggle with data, statistics, probability, and numbers. For example, the article noted how "people are flummoxed by numerical risk, paying more attention to numerators, such as '16 adverse events' than we do to denominators such as 'per million vaccine doses'" (New York Times International, September 26, 2019).

DATA, DATA EVERYWHERE

In today's world, we are inundated with so much information and data, that it often can be difficult to deal with. As we talked about in my previous blog article, we use heuristics to try and make sense of the world around us. Remember, these heuristics are meant to be simplified and quick shortcuts in our decision making and judgment. Interestingly, there is a branch of statistics known as 'intuitive statistics' which refers to our ability to make generalisations and predictions using our intuition and experience, reinforced by our heuristics.

Unfortunately, as noted before, this can lead to cognitive biases and systematic errors in judgements and decisions. One such bias that affects our judgments of data is the *information* bias which reflects our tendency to have a distorted perception of information and its significance. Put simply, statistics and probability are just not intuitive!

In one respect, we are not really interested in the numbers; rather we are interested in the outcome. For example, a 60% probability that it will rain tomorrow does not do me much good. What I am interested in is whether I will get wet and if I should bring an umbrella! Hence, we will make judgments and decisions seeking certainty (for example, an observation I've made to support this view is that people will often convert probabilities of occurrence that are <40% to 0% and ones that are >60% to 100% for just this reason).

MONTY HALL PROBLEM

Let's take a look at a famous example popularized in the "Ask Marilyn" question-and-answer column of the Parade magazine (see "Power of Logical Thinking" by Marilyn vos Savant, St. Martin's Press, 1996), and named after a famous game show in the United States.

Suppose you are on a game show, and the game show host gives you the choice of three doors. Behind one door is $10,000, and behind the other two doors are goats; and you are trying to win the money. You pick a door, say number 1. The host, who knows what is behind each door, purposefully opens another door that only has a goat behind it – say door #3. He then asks you "Do you wish to keep your original door #1 pick, or would you like to switch to door #2?" Is it to your advantage to switch doors, not to your advantage, or it does not matter?

If you have not seen this problem before, think of your answer. Most people say it does not matter as there is a 50-50 chance that the money is behind any one of the two remaining doors. This is not the correct answer, and actually you have a 66.67% chance of winning if you switch doors! I will leave it to you to research why, but suffice to say that Marilyn's correct response (note, at the time she had one of the highest IQ's in the world) caused an avalanche of correspondence, mostly from people who said her solution was wrong (including 65% who had a university degree, and 1000 with a PhD!) – one sample letter stated: "May I suggest that you obtain and refer to a standard textbook on probability before you try to answer a question of this type again?" (University of Florida, PhD)!

This apparently simple, but surprisingly complex, example illustrates how our intuition lets us down.

THIS INFORMATION IS SURELY REPRESENTATIVE

A shortcut that we often use to make judgments and simplify decision making about information is the *representative* heuristic, where we make judgments on how similar something is perceived to be to something else, often ignoring statistical evidence.

This heuristic leads us to systematically poorly predict the likelihood of an event and quantify uncertainty. We have a poor sense of what constitutes a random sequence, tend to underestimate the relevance of sample sizes, ignore base rates and dependencies (or not) between variables, are insensitive to prior probabilities and outcomes, and subjectively weight probabilities. Our judgments of data and probability are often distorted by our other cognitive bias. For example, the *availability* bias can incorrectly lead you to believe that the frequency that you have encountered something (particularly if it is an extreme or dynamic event) will imply that it is more likely to occur, which can be further reinforced *anchoring* and *confirmation* biases.

Let's take a look at a few of the *representative heuristics'* pitfalls.

RANDOMNESS

One of my favorites is how people underestimate the frequency and impact of randomness! Apple actually reprogrammed their iTunes shuffle feature to make it appear more random!

I remember when I was in university and taking a statistics class the professor would divide the class into two; one half he would have the class flip a coin 200 times and record their answers and the other half he told them to write down their own sequence of 200 flips. Without fail he could always tell which one of the groups actually flipped the coin and which ones were human generated – he just looked for a sequence of 5 or more. The human generated group would resist generating a long sequence because that is not their expectation of randomness. Perhaps to your surprise, the probability when flipping a fair coin 200 times of having at least one string of 5 or longer heads or tails is 99.9%!

BASE RATE

Our tendency is to focus on specific information and ignore what is generally true (i.e., *base rate*). In other words, we tend to ignore the probability of a specific phenomenon occurring, and rather focus on our specific observations of the event (which can be reinforced by the *availability* bias). For example, when we see a product advertisement of "50% extra free", our intuition thinks that half of the item is free; whereas when taking the base rate into account, it only implies that 1/3 of the item is free.

Bayes Theorem was applied by the US Government in 2009 to advise women in their forties with no relevant history not to have a routine, annual mammogram. The public reaction was immediate and enraged! Why did the US Government make this recommendation, and what were the public not considering? Answer next blog!

SAMPLE SIZE

People tend to believe that a sample population can be adequately represented with a selective or small number of data points and hence, place too much confidence in a small sample being representative of the general population**.** By its nature, a small sample is more likely to deviate markedly from the average of the population from which it is drawn; and although we know a large sample is better, we do not intuitively understand the difference between a small and large sample size and tend to equate them and our conclusions equally. Outcomes from a small sample can often look unrepresentative (e.g., flip 5 heads in a row). As noted above, that is not a biased outcome.

Interestingly, there are two aspects to the *sample size* heuristic – size and bias. We often just think of the former (i.e., how big of a sample we have); yet often a sample can be biased, which is a significant issue for pollsters. In our industry, it could manifest itself by using samples for our reservoir parameters only from one successful, adjacent field.

UNTIL NEXT TIME

On my next blog article, I will further explore the *information* bias and *representative* heuristic by interviewing two experts in our field. Peter Carragher (Rose & Associates) and Graeme Keith (Stochastic ApS) will give us some more insights on why we struggle with statistics and probability, and strategies on how to overcome.

Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#4 Information part 2

UNDERSTANDING AND OVERCOMING BIAS

Last time we talked about the *information* bias, and how poor we are at dealing with statistics and probability, often making irrational decisions. I would like to explore this bias further.

I left you with a question about the US Government's recommendation for women in their forties with no relevant history not to have a routine mammogram, and yet the public was overwhelming upset with this advice. Why did the US Government make such a recommendation? Because Bayes Theorem showed that given the low rate of breast cancer in women with no history of breast cancer, the uncertainties of the test reliability, and the risk associated with follow-up treatments this was the best course of action. Why were the public upset? Because they ignored the Base Rate!

OK; SO I'M NOT TOO BRIGHT WHEN IT COMES TO STATISTICS, BUT I GET BY!

As noted previously, our heuristics work generally well. But when we are working with our data and probability in our work in the hydrocarbon sector, these biases can wreak havoc with our interpretations, judgments, and decisions. I would like to bring two of my colleagues, Peter Carragher, Managing Partner Rose & Associates and Graeme Keith, Owner and CEO of Stochastic ApS to provide more insight into the *information* bias. Their wealth of experience and expertise should add some great insight into this bias.

Peter has over 45 years industry experience as a geoscientist, with extensive experience in designing exploration strategy, process, and organization capability. Graeme has a PhD in Mathematics, and he uses his vast experience in using statistical modeling to help geoscientists make better decisions.

Peter and Graeme have been invited to share their perspectives, one from a geoscientist and the other from a mathematician, on why we struggle with data.

THE GEOSCIENTIST …..

Marc: Peter, welcome to my Understanding and Overcoming Bias blog. I appreciate you taking the time to give our readers some of your insights on the *information* bias and the related representative heuristic.

> ***Peter:*** *Thank you for having me Marc.*

1. **Marc:** Ok, first question. Why do you think geoscientists are so bad at grasping the concepts of statistics and probability?

   > ***Peter:*** *Geologists and geophysicists are in general, as a class of people, very visually and spatially orientated; it is one of the great talents that we have. Geoscientists are able to think*

in three-, and even four-, dimensions. So, there are a series of thinking skills that are not present in the general population but are great skills for geoscientists. Given this hypothesis, geoscientists see what is 'available' in front of our eyes. The availability and the processing of available data is a fundamental root cause of why we can be poor at grasping these concepts.

This is exacerbated in that our task is to apply our expertise and experience to make estimates of both the presence and size a prospect, that is valid statistically, from a varied collection of often sparse well and seismic data.

2. **Marc:** Can you give us an example where you have observed the *information* bias and the impact it had on judgments and decisions in our industry?

   Peter: *What we have found in many years of training at Rose & Associates and many consulting reviews, we are systematically making these errors. For example, if we take the concept of porosity, the available data from our petrophysicists is generally a list of porosity values every 15cm; therefore, the available data is a list of numbers. However, what we actually need when we are doing a calculation of the resources in our prospect is the average porosity. The average porosity is not readily available; you have to work hard to figure out what the average porosity is from this list of numbers. Further, you have to determine the range of average porosities across the prospect. So, we have to go from the available list of numbers to an average (which in itself is conceptual); and then to determine the range of this conceptual number.*

   So although the geoscientists have the great skill of visually grasping the geology, it is harder to grasp the conceptual nature of the data. The good news is this is a learnable and trainable skill; it just needs constant care and attention to detail. Having a diverse group of people looking at these concepts and data is recommended.

3. **Marc:** I have heard you talk a lot about Performance Tracking. Can you tell us what you mean by this and why it is so important to mitigate the *information* bias?

   Peter: *As a team of assessors, we have to ask ourselves if we are calibrated on our resource and chance assessments. We only know this by looking at our previous performance, using an evidence-based approach to evaluating our predictions .You have to develop need properly calibrated assessments that are based on evidence from the data. Performance tracking is simply comparing your predictions with the actual outcomes, allowing you to become better calibrated and learn from your mistakes. It allows you to look-back at a series of events and measure whether or not people have captured the range of uncertainty in their decisions.*

   A fundamental issue of Performance Tracking for many companies is that it is a real-score card of whether or not you delivered on what you predicted. This can be particularly challenging if you are an individual business unit that is not drilling many wells. Hence, it is imperative that performance tracking has to be done on a company-wide aggregated manner in order to make any statistical valid judgments. Unfortunately, what we have observed in our work with companies is that some companies do not undertake performance tracking and sharing of learnings on a systematic basis. If there is anything that should not be a variable commitment in our industry, it is performance tracking. This strikes me as a major shortcoming in our industry that we do not rigorously performance track everything, including our exploration subsurface predictions. The only way you can learn and become calibrated, and therefore attempt an intervention, is to know how well you did.

4. **Marc:** Can you give us an example where this technique has had a positive influence?

   Peter: *A great example is the Rose & Associates DHI database of several hundred wells which consistently assess a prospect for DHI properties. Many lines of evidence are methodically evaluated, which allows us to have a reliable chance of success estimation for the prospect that is calibrated against a large dataset. Taking the guesswork out of subjectivity is what we are trying to do.*

5. **Marc:** So, are we just a victim of our own mental shortcomings or is there something we can do?

   Peter: *Over the past few years "big data", "Artificial Intelligence", and related subject matter has come into vogue in the oil & gas industry. At a deeper level this is suggesting that the answer is in the data; so, if we throw enough data into a machine, we will come up with a correlation which can drive to the answer which we could not see before as our brain cannot absorb such a large amount of data. These techniques are trying to mitigate our biases; however, whether the programming of the machines is introducing the biases of the analyst is a subject of another discussion! I think there is a role for artificial intelligence in the future to process data which can help us to make better, unbiased judgments and decisions.*

THE MATHEMATICIAN …..

Marc: Thank you Peter. Graeme, thank you for joining us.

Graeme: *It's great honour to be invited to your Bias blog.*

6. **Marc:** I know you are not a geologist, but from your perspective, why do you think us geoscientists get it wrong so often?

   Graeme: *Well first, I'd really like to say what an astonishing accomplishment it is to be able to say as much as you can say about what the subsurface looks like at several kilometers of depth on the basis of staggeringly detailed and accurate accounts of what happened millions of years ago. I really got into the subsurface end of upstream oil & gas ten years ago, and that sense of sheer awe at that colossal intellectual accomplishment never left me. It's an incredible multi-disciplinary effort with astonishing levels of ingenuity in every discipline. And the exploration geoscientists who are able to master and synthesise this knowledge are, honestly, the constant object of my deepest admiration.*

   But that said, what strikes me is the contrast between the depth and brilliance of the geoscience that goes into working up a prospect and what to my mind seems like at best very simple, and at worst hopelessly naïve, practice around the quantification of uncertainty and the way in which that quantification is used to make decisions. I've seen project teams wait three months for a sequence stratigrapher with post-doctoral research qualifications in exactly the relevant epoch for the prospect in question, but the same team doesn't hesitate to take all the results of that analysis and cram it into a quantitative model that frankly any first-year math student wouldn't hesitate to kick on to the scrap heap.

   I do think geoscientists get it right an astonishing amount of the time, but I also think that a lot of that sense of disappointment of poor performance (i.e., lower resources than expected) comes from really quite naïve practice and logic around how we quantify uncertainty and make probabilistic predictions.

My observations are that we are fairly good at chance assessment, although at times overenthusiastic; rather, it is in our estimation of resources where we go wrong. More generally, doing statistical work well is difficult; statistics and probability are not easy concepts, and people make 'rules of thumb' and use heuristics. People try to persuade themselves they understand the uncertainty and use intuition that are disconnected from the simplest principles of mathematics, which in turn can lead to poor judgments and decisions.

For example, I have seen companies fix the low (P99) value of a probabilistic distribution of resources to a specific value such as 1mmboe. In principle this is good, in that they are recognizing that their predicted resource ranges are too narrow with the low end of the distribution too high. However, this becomes a "rule" company-wide that people blindly follow. Whereas it may be appropriate for a specific basin or play, it can be completely and utterly wrong in another basin.

I have found that geoscientists will incorrectly apply the more simplistic statistical situations, such as flipping a coin or rolling a die, to the more complex uncertain environments. Statistics and probability are not easy concepts, and one needs an immense amount of experience and knowledge to understand the inherent nature of uncertainty, just as the geoscientist needs to understand the subsurface.

7. **Marc:** Ok; fair enough; but then why do we often do get it right? We have found an incredible amount of hydrocarbons through our ingenuity and creativity, and I don't buy the concept that we were just lucky as others have suggested; rather, we tend to make our own luck (i.e., skill meets opportunity)!

   Graeme: *I think the luck question has two components. There is a sense that when we say we were "lucky", it is really saying we're rubbish and that any success we have is just good luck. I don't buy that. Sure, we can be a lot better at articulating our uncertainty mathematically and both optimizing our portfolios and managing our investor expectations as a consequence, but where we drill is overwhelming much more driven by what we're good at (i.e., geoscience) than what we're bad at (i.e., putting numbers around it).*

   The other sense of saying we're lucky is just recognition that the subsurface is massively undetermined by the data we have. It is simply not possible to distinguish success and failure cases based on the data we have before we drill. This is unavoidable. The consequence is that our statistics are incredibly volatile. And that means that the best geoscience in the world is going to have bad runs. And there is always the chance that mediocrity will have a good run.

   What's interesting is how many wells you have to drill that your run of luck actually reflects how good you are and not just the statistical whimsy of the day. Therefore, one must drill many wells to make statistical valid judgments (however, even with a small number of wells drilled, you can still gain a good understanding of how good your predictions are and become better calibrated). I would expect that by looking at the industry as a whole many of the cognitive biases you teach in your course will cross company boundaries, but I think the information bias is more company specific. In both cases, the idea is to capture the biases, feedback to the teams, put in place bias mitigation strategies leading to improvement of workflows. From my limited experience, though, companies that have conquered bias are few and far between.

8. **Marc:** For a probability perspective, what do you think is our biggest issue?

Graeme: *Hard to choose! Some problems are common, but not that disastrous; and others are disastrous, but not that common.*

If I were to plump for something that was a bit of both, I'd say it was a tendency to take models and interpretations off the table too early, effectively ruling out entire categories of entirely plausible outcomes, and then spending way too much time and effort refining what's left.

I often hear that we don't do that is because we don't have time to model everything, but I think that misses the point and is an easy excuse. The basic level of uncertainty is what-does-this-thing-even-look-like level, so refining a single interpretation much below this level of uncertainty is just modelling under the noise floor. This practice, rather than reducing uncertainty, is ignoring it. It's far more correct to leave all the conceivable interpretations on the table and model them at a more appropriate, coarser level.

After that, I think confusion about to what events you're assigning a probability and how the resource distribution relates to those events is a common problem. This is just a question of definitions and a quick win to remedy. For example, you sometimes hear a lot about risking the P99 value. While this is vocabulary rooted in basically sound practice, it is both incorrect vocabulary and mathematically nonsensical; and that kind of logical sloppiness can easily get you into trouble.

9. **Marc:** Can you give an example of where you have seen mathematicians influenced by the *information* bias?

    Graeme: *The ability to communicate the uncertainty to the prospect assessors and decision makers. Statisticians make probabilistic statements, yet they can often be too dogmatic that their model is the right one often ignoring the uncertainty. I have also seen the opposite where statisticians say that they are utterly unwilling to say anything without an enormous amount of high-quality data.*

FINAL WORDS …..

10. **Marc:** If you could leave us with just one single piece of advice in helping to mitigate the *information* bias, what would it be?

    Peter: *Perhaps simply I can leave you with this quote by the philosopher Will Durant, based on Aristotle: "We are what we repeatedly do. Excellence, then, is not an act, but a habit". In other words, develop rigorous and systematic best practices, and stick to them.*

    Graeme: *Recognise that your geoscience workflow is only as good as the final step where all that work and knowledge is turned by teams into a handful of numbers, and that all that amazing work can go straight down the drain if that step is not exposed to as much scrutiny and rigour as everything else you do. To address this, we should get engineers and economists involved upfront to help understand the project drivers and put in place the workflow required.*

Marc: Peter, Graeme. Thank you for participating in this interview and sharing your insights.

UNTIL NEXT TIME

On my next blog article we will talk about the relationship between bias, evolution, and creativity.

As the year ends, I would like to wish everyone all the best for the Holidays and a more “normal” New Year!

Stay safe and healthy.

Marc Bond
Rose & Associates.

BIAS

#5 Evolution

UNDERSTANDING AND OVERCOMING BIAS

In an earlier blog article, we noted that our cognitive biases are 'normal', and that we all have them. This leads to a natural question: Where do these biases come from? Is there perhaps an evolutionary basis to our biases? Let's explore.

BIAS AND EVOLUTION

On the surface, our cognitive biases are somewhat puzzling. If they can lead us to poor decisions, that would suggest they are a design flaw, and so why would they have survived as we evolved? However, from an evolutionary perspective we are not interested on how accurate or logical our cognitive abilities are, but rather how well they solve a particular problem and how solving this problem contributed to our survival through natural selection. Viewed in this way, if a cognitive bias positively contributed to our evolution, it would not be a design *flaw*, but rather a design *feature*![1]

HEURISTICS

Let's take a simple example. As humans, we are particularly good at pattern recognition. So, let's say we are walking in the forest and we see the bushes rustle and we think we see a tiger, and we decide to take an alternate route. However, this might not be optimum way as if we would have continued in the original direction, we might have discovered something important, such as a source of water. However, from an evolutionary perspective nine false positives (i.e., think we see a tiger, but it is an illusion) is a much better strategy than one false negative (i.e., don't think it is a tiger, but it is!). Hence for our survival, it is best to go another way!

Because information processing time and capacity are limited, we use a series of mental shortcut strategies, known as *heuristics*, to help us quickly solve problems, form judgments, make decisions, and evaluate the world around us. This is our *reflexive* (as opposed to *reflective*) thinking.[2] We rely on these unconscious shortcuts to reduce the complexity of tasks. They have served us well, as 'good enough', faster, and less use of cognitive energy is a more adaptive strategy for survival.

A good example of how we use heuristics is when we cross the street. If you were to use your *reflective* thinking you would look one way, estimate how far away and how fast any vehicles are traveling and incorporate any other danger you observe. You would then need to look the other way and do the same estimations, which of course might invalidate your first assessment as a car could be approaching and so you would need to re-look in the first direction; a process continuing ad infinitum. You would never cross the street! Rather, you use your *reflexive* thinking, quickly recalling past experiences and apply your intuition to safely cross the street.

Let's take a closer look at a few of our cognitive biases and see how they serve an adaptive function that could explain their role in natural selection. Interestingly, research has shown that many primate species share similar biases as humans. For example:

- *Anchoring* bias – enhances our superior ability to make relative judgments
- *Availability* bias – supports our ability to make rapid judgments when time is limited
- *Confirmation* bias – strengthens our ability to persuade others and "win" arguments
- *Information* bias – uses less cognitive energy
- *Overconfidence* bias – improves our ability to succeed in difficult situations

Heuristics are a lot like a Swiss army knife – each part solves lots of problems generally well, but not optimally (have you ever tried to use the saw blade on the knife?!). Research estimates that we are exposed to 11 million pieces of information at one time, but we can functionally only deal with 40. Hence, our heuristics have distinct advantages (i.e., reducing time and effort required to make reasonably good judgments and decisions) and yield fairly good outcomes.

IF THESE ARE SUCCESSFUL EVOLUTIONARY STRATEGIES, THEN WHAT'S THE BIG DEAL?

Heuristics are good strategies to employ, yielding answers that are approximately correct or more likely to work; but often 'fairly good' is not good enough. Our world has transformed from the 'simpler' world of our ancestors, and we are dealing with far more complex problems in which our heuristics let us down and are often not the best answer nor lead to good decisions. We can think of these heuristics as the foundation of our cognitive biases.

For example, the *anchoring* bias is a heuristic where we anchor our evaluation on some reference value, and then shift up or down to reach an answer that seems plausible. The problem is that we usually do not shift our estimate far enough away from the anchor value. Think about buying a car. The dealer shows you the Manufactured Suggested Retail Price. Dealerships enhance their profits as you immediately anchor on that value and then negotiate downwards, but almost always never sufficiently enough to an advantageous price. Dealers take great strides not to inform you what they paid to have the car in their showroom.

When it comes to risk, we are particularly good at assessing it. However, we struggle estimating uncertainty, which we characterise by expressing in a range. But let's think about this from an evolutionary perspective. I most certainly care if there is a tiger in the bushes (risk); but do I really care about whether the tiger may or may not be hungry (uncertainty)?

My observation assuring prospects for clients is that we are very good at understanding risk, from which we can estimate a probability of success. Post-well analysis of yearly (or multi-year) exploration drilling programs shows that many companies often effectively estimate the success rates from their chance assessment.

However, from an uncertainty perspective, our ranges for prospect size is way too narrow and optimistic, with results often significantly below predictions. Too narrow a predictive range suggests the *overconfidence* bias, which is the tendency to overestimate the accuracy of our own interpretation, judgment, or ability. This bias is endemic within our industry, and we see it in our data interpretations, resource estimation, and timing in project planning, for example.

This overconfidence can be exacerbated and reinforced by many other cognitive biases, such as the *anchoring* and *confirmation* biases to name a couple. For example, one may anchor their upper and lower bounds of their resource assessment too close to their perception of the 'best estimate', resulting in too narrow of a range. The *anchoring* bias could be reinforced by the *confirmation* bias

(our tendency to seek data that only confirms our interpretation), thus supporting the more optimistic geologic model.

There are several mitigation strategies that we can employ, but one very good one is to undertake reality and plausibility checks of our interpretations, assumptions, and estimation.

DOES THAT MEAN I AM A PRISONER OF MY BIASES?

When I teach my Mitigating Bias course, I am often asked why I don't give strategies to get rid of the biases. First, we never could get rid of them as they are useful, evolutionary strategies as noted above. Second, given that these biases (and hence, *heuristics*) have a positive function, we need to learn when these biases negatively influence us and then learn strategies to mitigate. My experience is that these will be in environments that are uncertain and complex, which pretty much sums up the hydrocarbon industry!

Good decision making comes from the successful interplay between *reflexive* and *reflective* thinking strategies. An example to show this is to think of the Chess Grandmaster. They can look at a chess board position and immediately analyse, saying for example, "checkmate in two moves". They are clearly using their *reflexive* thinking when they make that observation. However, it is backed up by years of training, study, and play (i.e., *reflective* thinking), giving the Grandmaster proficiency and skills.

BIAS AND CREATIVITY

I would like to leave you with an idea to consider: **Do cognitive biases enhance our creativity or do they impede it?** (I'll use the definition of creativity as "using imagination to create new ideas", such as the hydrocarbon potential in a new play or basin).

At first glance, it would seem that our cognitive biases limit and inhibit our ability to come up with creative and innovative ideas and solutions. For example, if I am always looking for data to confirm my hypothesis (c*onfirmation* bias), I will miss other alternatives. Or I might rely on my past experiences and prior knowledge (*availability* bias) which may limit my ability to think divergently.

Yet perhaps, like the crossing the street example, if I am so focused on my *reflective* thinking, perhaps I might miss the 'big' ideas. Many people believe that too many rules, that can come from invoking our *reflective* thinking, can stifle creativity; and perhaps to the contrary, specific biases may help me to be creative. For example, the *availability* bias may help me to focus on successful geologic play types; the *information* bias may get me to ignore the low base rate associated with analogs of an opportunity; and the *overconfidence* bias can motivate me to portray the upside in a play.

What do you think? Enhance creativity or impede creativity? Post a Comment.

UNTIL NEXT TIME

[1]Take a look at a publication by Haselton et al (2015) about the Evolution of Cognitive Bias, which I found to be quite interesting.

[2]Please see my earlier blog article that discusses *reflexive* and *reflective* thinking.

On my next blog article, I will explore one bias that particularly annoys and frustrates me when I observe it – *confirmation* bias!

Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#6 Confirmation

UNDERSTANDING AND OVERCOMING BIAS

All the biases can negatively influence our judgments and decisions, but the *confirmation* bias has a dark side!

WHAT IS CONFIRMATION BIAS?

Confirmation bias is the tendency to search for, interpret, focus on, and remember information in a way that confirms one's belief or hypothesis.

Rather than explain, let's see how this bias can play out.

You have all seen something like this before. I have a sequence of numbers which conform to a rule that I have in mind*, for example: 1, 2, 4 and I ask you to figure out a valid next number in the sequence and then state what is the rule. With each guess, I will tell you if the number conforms to the rule or not; you can guess as many numbers as you want until you are ready to say the rule.

What normally happens is that you form a model in your mind and then test it. Say something like "the model is a repeat pattern" and then you test it by guessing the number 1 that fits your model. If that fails, you'll try another model and look for numbers that confirm to your model. However, if you test it a few times and find the numbers you guess fit the rule, you will tend to stop your testing and announce my defined rule. This is known as the "Positive Test Strategy", which can be a useful heuristic. In other words, you are looking for data to confirm your model. The problem is that we lose site that data can support more than one model, and thus tend to be lazy when we see data that fits our model and jump to the conclusion that we are right.

Why do we do this? Because it is easier to try and confirm something than it is to disprove. Try it on something you strongly believe is true by looking for data and see how you react to what you find.

In the E&P business, an example of confirmation bias was shown in my first blog article where you could purchase two wells to test your model. Another example would be the positive feeling you have when a piece of information conforms to your hypothesis.

AND PERHAPS EVEN WORSE …..

The dark side of this bias is the corollary … we so easily will ignore, dismiss, or underweight data that contradicts our belief or hypothesis. You see people doing this with their stock investing research by only studying the reports that lead to a 'buy' recommendation), or with political beliefs when faced with information or data that conflicts with their point of view. Unfortunately, I see this a lot in our industry. For example, an interpreter disregards a new well or seismic line which does not support a geologic model, justifying it away by saying it is old or poor-quality data.

This approach is contrary to the scientific method which involves forming a hypothesis, undertaking careful observation, testing of data, and applying a rigorous scepticism about what is observed and how it fits into your hypothesis. In other words, rather than trying to confirm your hypothesis, you should try to disprove it. If you cannot, then your model is still valid.

One way to mitigate *confirmation* bias is to write down your beliefs and justifications and then actively seek out data to disconfirm. Frame any questions in a way that encourages disconfirming answers. If you cannot find any evidence, then your model will now be more conclusive; however, with the understanding that there still can be doubt. One of the world's most successful investors over the last four decades, Warren Buffett (who owns significant positions in several major companies) invites stock analysts who suggest not buying his company's stock to his annual meetings, so that the investors experience disconfirming evidence.

P.S. The next number in my sequence would be 14 … the next number, when written in the English language, that has the letter 'o' in it!

UNTIL NEXT TIME

On my next blog article, I will explore an incredibly influential bias that is not a cognitive bias – the *motivational* bias!

Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#7 Motivational

Motivation is defined as a desire or willingness to do something in a particular way. That seems to be a good thing. However, when it becomes a bias that can lead to some disastrous consequences.

MOTIVATIONAL BIAS, WHAT IS IT?

Motivational bias is a tendency to take judgments or decisions based upon a desire for a particular outcome. This is linked to what is known as the *outcome* bias, which is the tendency to evaluate decisions based on the potential outcome rather than the quality of the decision at the time it was made. Unlike a cognitive bias, the *motivational* bias is generally a conscious action often motivated by one's own self-interest or a desire to align with a real or perceived expectation.

Whilst the concept of being motivated is considered a positive trait, as a bias it can negatively affect estimates, forecasts, judgments, and behaviours, potentially leading to bad decisions. The literature is littered with examples of disastrous outcomes for the public; for example, the companies motivated to lend sub-prime mortgages for revenue gain in 2008 contributed to a worldwide financial crisis; or Volkswagen, who to avoid paying fines, installed software that gave deceptively low results in emissions tests.

Examples of poor behaviours in the hydrocarbon industry include overstating prospect size or production forecasts, underestimating the cost and time for project completion, downplaying or ignoring uncertainty and risk to make their project appear more viable, or managers telling their staff to ensure the prospect resource potential meet a commercial threshold. Whilst all these examples are extreme, more subtle motivations, even if unintended, can influence individuals and lead to poor decisions. Many motivation drivers are unwritten and could be what the individual perceives is wanted by management.

When I teach my Mitigating Bias course, the *motivational* bias topic often engenders a great deal of debate and frustration amongst the students. Here are just a few of the examples they have shared with me.

- They'll get the message: "I would never drill a well that had a Chance of Success less than 20%"
- Or the more subtle: "I want you to do your best technical work, but we really do need this project to go forward"
- And perhaps the least subtle of all: "Change your numbers"!

INFLUENCE IN HYDROCARBON INDUSTRY

Let's be serious. None of us want to follow the rainbow looking for a pot of gold and find nothing! We all hope to find an exciting play or work up a prospect to a drillable status. It is human nature that professionals champion their projects and want to see them progress from exploration to production.

There really is not a whole lot of recognition in 'killing' a prospect! And we have management who consciously or unconsciously incentivizes us to deliver successful outcomes. How many times have

you been rewarded for a negative recommendation, such as relinquishing a license? Actually, such a recommendation can be quite valuable for a company, avoiding further poor investments, including drilling a dry well.

One area that sets our industry apart from many others is the long lead time required from the inception of the technical evaluation, the development of the recommendation, and then ultimately the actual outcome. This can lead to poor behaviours as teams want to be optimistic and progress their projects, and thus may overpromote their opportunity. Given the time lag, these poor decision quality behaviours may often not be captured; and the recommendations and evaluations may possibly even be rewarded through compensation and/or promotion!

Teams are often incentivized to 'sell' their project, and their judgments and decisions can be further accentuated by cognitive biases (e.g., *anchoring*, *confirmation*, *overconfidence*, etc.) that help justify a recommendation.

There can also be unintended consequences relating to a seemingly good motivation. For example, let's say the Head of Exploration wants to increase their prospect inventory. To incentivize staff, they introduce a performance metric for each team to deliver by year-end three prospects to the inventory, each with success case volumes exceeding a specified amount, and they will be rewarded accordingly. What will the evaluation teams generate by the end of the year? Three prospects per team with the specified volume. Will all the prospects have any realistic chance of reaching or exceeding that requested volume? Doubtful! Is that really what the Head of Exploration wanted delivered? No!

IT'S MORE OF A MANAGEMENT RESPONSIBILITY

Perhaps the single most important issue with *motivational* bias is that it is often exacerbated by management goal setting. Individuals can be aware of this bias and try to avoid, but any significant mitigations must come from management design of goals and targets. Ultimately this affects companies' performance. I like to say that the *motivational* bias is more a 'top-down' one (i.e., external from yourself) where cognitive biases are more a 'bottom-up' (i.e., internal to yourself).

Hence, management must design reward and incentive systems that encourage not just achieving the predicted outcomes, but also instilling the right behaviours and best practice decision-making processes to achieve those outcomes. Prior to implementation they should also consider if the rewards may negatively influence people's behaviours, leading to unintended consequences.

Focusing on the process rather than the outcome seems more sensible when there is more risk involved (e.g., exploration) in that the outcome could be related to randomness, luck, or external factors. However, even in low-risk industries, focusing only on the outcome could be problematic. For example, making 'widgets' is pretty straight-forward, and so management decides to reward employees that make more 'widgets' than average. Good motivation? Perhaps; but, perhaps not. Maybe by rushing to make a greater number of 'widgets', the quality goes down. Or, maybe an employee concentrates on not making more 'widgets', but rather on coming up with a more efficient process for making 'widgets'. Rewarding the innovation would be a far better approach than the outcome of simply making more 'widgets'.

MANAGERS PERSPECTIVE

Managers have seen throughout their career the impact of *motivational* bias. I interviewed a senior manager (VP Exploration) to get their unique perspective for this blog He clearly recognises that this can be endemic in an organization leading to poor decisions and loss of value. A challenge in the organization is that activity drives everything, more that it should. Hence, at all levels, people will be

incentivized to deliver opportunities, which can drive poor behaviours that can lead to poor decisions. This conundrum needs to be acknowledged.

He presented an example of motivational bias at his level. Exploration was looking at the acquisition of a particular license in a new country. They came up with a value of X (NPV, size, chance) and presented this to their Executive Committee (EC). Unfortunately, the value X was below the price wanted by the seller. The EC asked him to re-evaluate the opportunity and increase the exploration value to make it equivalent to the asking price as the company was keen to enter the country. He declined to do this, but rather suggested instead to add a strategic element (e.g., value of country entry) to the opportunity. The EC would not do this and wanted exploration to shoulder the risk. The VP Exploration stood his ground but noted how easy it would have been to "re-evaluate" the opportunity and increase its value.

He noted one problem for the decision-makers is that they are usually too far removed from the opportunity. The Regional offices are clever enough to put pressure (subtle or direct) on their staff to "inflate" the numbers and will come to the decision-makers with a polished presentation to promote their prospect. This is hard for the decision-makers as they are very much at the mercy of the optimistic frame. This is one reason he relied on an independent assurance team to provide credibility to the presentation.

He believes that within exploration the focus must move from the individual opportunity to the success of the exploration portfolio. Incentives and rewards, whilst acknowledging personal performance, should take a more holistic view. Unfortunately, it is easy to say as we are all human!

UNTIL NEXT TIME

On my next blog article, I will interview Creties Jenkins, co-creator of the Mitigating Bias course.

Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#8 Biases and Illusion

Today I would like to talk with Creties Jenkins, co-creator of our *Mitigating Bias, Blindness and Illusion in E&P Decision Making* to gain another perspective of bias and how they impact our interpretations and decisions. Creties is a Partner at Rose & Associates with 35 years of diverse industry experience. As a geological engineer, he compliments my geoscience background.

INTERVIEW

Marc: Creties, welcome to my Understanding and Overcoming Bias blog. I appreciate you taking the time to give our readers some of your insights on our course.

1. **Marc:** I'd like to ask you what inspired you to put together the Mitigating Bias course.

   Creties: *First off Marc, thank you for the opportunity to provide some commentary for the bias blog. My primary inspiration for the Mitigating Bias course was Pete Rose's AAPG Distinguished Lecture called "Cognitive Bias, the Elephant in the Living Room of Science and Professionalism", which can be viewed on YouTube. He made the point that our lack of objectivity, due to errors in thinking, contribute to underperforming projects and portfolios. He also noted that the biggest challenge is convincing technical and management professionals that they are subject to bias, and concluded his talk by calling for renewed commitment to the 'rigor of the scientific method'. This is where our course picks up in order to provide some practical guidance.*

2. **Marc:** In the course we talk about Illusions. Can you give us some more insights?

   Creties: *We define an 'Illusion' as a misleading belief based on a false impression of reality. We focus on the Illusions of Potential, Knowledge, and Objectivity. Illusions are fueled by biases—we anchor on supporting data, we ignore disconfirming information, we become overconfident in the expected result. My grandson, who's a big superhero fan, was crushed when the Superman cape he ordered didn't give him the ability to fly around the house. It never occurred to him that if this was real, friends and family members would already be using them. He was blinded by his own reality, which can happen to us as well.*

3. **Marc:** Can you give an example?

   Creties: *All of us have seen Executive and Technical presentations touting the game-changing advantages of a given project, transaction or technology in our industry. We've come to expect that companies will overstate their knowledge and potential of these opportunities in order to generate investor buzz. But more importantly, we see companies believing their own press and not thinking critically enough about their proposed investments or having processes in-place to rigorously assess them and apply the lessons learned to new projects. The "Shale Revolution" in North America is a good example of companies repeatedly overpromising and underdelivering.*

4. **Marc:** Do you see a relationship between Illusions and Cognitive Biases?

   Creties: *I do think that cognitive biases fuel illusions. We focus on small bits of data and analogs (information bias) that favor our intent (anchoring bias), ignores conflicting information (confirmation bias), convinces us that our strategic plan is correct (framing bias) and that fame and glory will follow (motivational bias). So we think opportunities are better than they are (illusion of Potential), that we understand them more deeply than we do (illusion of Knowledge), and that we're being honest and impartial in our resulting decisions (illusion of Objectivity). Without a constant awareness of this state and the application of mitigation techniques we teach in our course, this sequence is all but certain to repeat itself. Just about every person reading this can recall at least one project in their company that followed this pattern with a disastrous result. And yet the cause and cure still receive scant attention.*

5. **Marc:** What is one of your most surprising observations when teaching the course?

   Creties: *What's most surprising to me is how few companies are interested in assembling case studies of their project failures and understanding the role that cognitive errors like 'Illusions' played. These case studies are really powerful because you have to admit that if a failure happened once in your company, it could happen again without some changes. I saw this first-hand at ARCO where the Illusion of Knowledge (mistaking familiarity for real understanding) led to a failed waterflood project because of unrecognized connected natural fractures. The inability to learn from this led a decade later to a billion-dollar failure of a miscible gas injection project for the same reason.*

6. **Marc:** What is your biggest learning from teaching the course?

   Creties: *How prominent and impactful these cognitive errors are. We've presented this course nearly 100 times to everyone from field personnel to executives and nearly every attendee (based on course reviews) sees this problem within their company. Yet most companies are not addressing it or think it's sufficient for personnel to simply have awareness. I did a half-day leadership version for one company and was told afterwards that the attending geoscience managers favored a 2-day mitigation course for their reports, while the engineering managers favored a 1-day awareness course for their people. This led one of the geoscience managers to remark that geoscientists were interested in addressing the problem while the engineers were only interested in identifying it in others!*

7. **Marc:** And could you leave us with a final message for our readers?

   Creties: *We provide our course attendees with an understanding of the different types of cognitive errors along with examples and steps to mitigate them in their daily work. But to create change, everyone in the organization needs to have a common vocabulary and processes (e.g., framing sessions, peer assists, performance lookbacks) that will expose and lessen the impact of cognitive errors. HR departments understand how these errors affect hiring, performance reviews, promotions, and employee interactions. We need the same recognition and desire for change on the technical side.*

UNTIL NEXT TIME

On my next blog article, I will discuss some recommended readings on the topic of bias.

Please visit our website to view other Rose & Associates blogs.

Stay safe and healthy.:

Marc Bond

Rose & Associates

BIAS

#9 Recommended Readings

As I build, update, and improve content for my course on bias, I compiled an extensive bibliography with over 100 entries and a slimmed down version of suggested readings. This blog explores a few of those references.

IF I ONLY WERE TO RECOMMEND JUST ONE BOOK…

…that would be Daniel Kahneman's Thinking, Fast and Slow[1]. Daniel Kahneman and Amos Tversky pioneered research on cognitive bias. His book clearly outlines the subject, delving into the story behind many of their ground-breaking publications. Whilst technical, it is very readable.

I expect many of you are familiar with this book, and hence I will address a few others.

A FEW OF MY RECOMMENDATIONS

I wanted my recommended references to suitably outline the concepts, but at the same time serve as a clear and relatively easy read. Listing my suggestions alphabetically by author,

1. **Predictably Irrational by Dan Ariely (2008)[2].** Dan Ariely is a psychologist and behavioural economist, and he uses his expertise to weave the two professions together to better understand human behaviour. This book is both highly entertaining and thought provoking. Using a series of examples, experiments and anecdotes, he demonstrates how we make seemingly irrational choices and decisions, and yet we do not seem to learn from those mistakes repeating the same pattern over and over. As the title says, predictably irrational!

2. **The Critical Thinker's Dictionary: Biases, Fallacies, and Illusions by Robert Carroll (2013)[3].** Robert Carroll is a professor, focusing on philosophy, logic, and critical thinking. His book explores over 100 of the biases and illusions. Immensely entertaining and easy to read, he structures the topics like a dictionary with several pages dedicated to each. He defines each of the biases, supplying examples and research studies to support the narrative. I especially like at the end of each topic; he provides a short list of references. He covers most of the common biases and illusions, but also some more esoteric ones such as the 'Texas Sharpshooter fallacy'!

3. **The Art of Thinking Clearly by Rolf Dobelli (2013)[4].** Rolf Dobelli is a businessman. At first glance, this might be an odd choice for a recommendation. It is not founded in his research studies, yet it is an incredibly practical and readable book to explain and demonstrate a multitude (99) of biases and illusions. Unlike the Critical Thinkers Dictionary, he succinctly presents the error in judgment, explaining each and using examples to show how they present themselves all in three pages per bias!

4. **The Psychology of Judgment and Decision Making by Scott Plous (1993)[5].** Scott Plous is a professor of psychology. The book focuses on many of the biases that impact our judgments and

decisions, and clearly describes them using studies and simple examples to reinforce the concepts. He uniquely starts with 39 questions for the reader to answer. The questions are drawn from many of the studies discussed throughout the book. Readers can compare their answers with the responses given by people in the original study.

5. If you are interested in a paper that refers specifically to cognitive biases in the petroleum industry, I recommend **Cognitive Biases in the Petroleum Industry by Welsh et al (2005)[6].**

A WORD OF CAUTION

Most all the references address cognitive bias, outlying how irrational we are and the negative consequences related to these biases. However, there is sparse information on what you can do about them. For many of the references I have read, the discussion focuses on the subject and problems with bias with the conclusion suggesting there is not much you can do other than providing a few mitigation suggestions. This fundamental lapse common in the literature is the driving force behind building the Mitigating Bias course, providing mitigation strategies for each bias.

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[5]Plous, Scott, 1993, The Psychology of Judgement and Decision Making, McGraw Hill.

[6]Welsh, Matthew, Bratvold, Reidar, and Begg, Steve, 2005, "Cognitive Biases in the Petroleum Industry: Impact and Remediation", #96423, SPE Annual Technical Conference and Exhibition, 9-12 October 2005.

What reference recommendations do you have? Please post in a Comment.

UNTIL NEXT TIME

Next time … *anchoring bias*, perhaps the most insidious and robust of all the biases!

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Marc Bond
Rose & Associates

BIAS

#10 Anchoring

Anchors Aweigh!

Where *confirmation* bias has a dark side, the *anchoring* bias is perhaps the most insidious and remarkably robust of the cognitive biases. BEWARE!

ANCHORING BIAS

Earlier articles in this series mention the *anchoring* bias (the tendency to 'anchor' on some reference value or piece of information), which leads us to not diverge (i.e., move away) sufficiently enough from the anchor, regardless if we adjust from a high or low anchor. Given the insufficient adjustment, our final estimates are biased towards the initial anchor value.

Countless studies (e.g., Kahneman, 2011; Ariely, 2008; Plous, 1993) show that when people are given a reference value and then asked to estimate something (e.g., cost of item, population, etc.), they invariably stay close to that anchor and estimate poorly. For example, studies show that judges can be influenced by a prosecutor's demand for a length of sentence in their closing argument, as this provides them with an anchor. (See Blog Article #9 for references)

This bias works because we are so good at judging attributes or merits relative to one another, and hence let our estimates stay close to an 'anchor' that previously entered our thinking.

What is so insidious about the *anchoring* bias is that the reference value can be completely unrelated or uninformative to the question. For example, researchers asked participants to write down the last two digits of their social security number (i.e., government ID number) and then to estimate the cost of an item. Those with high numbers estimated a high value, and those with low numbers estimated the cost significantly lower. An arbitrary two-digit number, and yet it clearly affected the estimations.

This bias can have significant negative consequences for us. For example, people are often focused on their purchase price (i.e., the anchor) of a particular stock, ignoring current pricing or fundamentals of the company when deciding if they should hold or sell the equity, sometimes at their detriment.

AND THE RELEVANCE TO E&P BUSINESS …..

The anchoring bias is quite prevalent in the E&P business and can have significant ramifications on interpretations and decisions. For example, focusing on a single reservoir parameter when estimating porosity, rather than what the porosity could average across the trap; expressing a view of chance of success for prospect considering only one geologic model, without considering the other possible scenarios; or focusing on the 'sunk cost' when making a decision about an opportunity.

The data and numbers in our evaluations provide us with anchors, which is further exacerbated when the sample size is small. By focusing on the anchor and not the range of possible outcomes (including small analogues), we tend to end up with too narrow of a range, and the outcome often fall outside of that range.

WHAT CAN I DO?

The *anchoring* bias can be so pervasive and powerful that it can be exceedingly difficult to mitigate. Studies have shown that incentives or awareness alone have a minimal impact on reducing the *anchoring* effect.

One of the first mitigation tactics is to shift focus off of the reference value, being aware how this can influence your judgment. You can do this by discounting or ignoring a completely divergent anchor; although it can be difficult to do so. For example, if the Manufactured Suggested Retail Price (MSRP) of a car is $20,000, your first negotiating tactic could be to offer a (not too) absurdly low price like $15,000. You now have two anchors, and both of you will negotiate away (car salesperson from $20,000 and you from $15,000). You should end up with a final sale price lower than if you would have just focused on the MSRP. In other words, work with multiple anchors. Similarly, relating this approach to the oil and gas industry, consider more than one analogue for your prospect.

UNTIL NEXT TIME

The next article in this series will explore if we are really irrational creatures as suggested by the definition of cognitive bias!

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Stay safe and healthy.

Marc Bond
Rose & Associates

BIAS

#11 Irrationality

ARE WE IRRATIONAL?

Literature on cognitive biases is littered with phrases saying what irrational creatures we are. There is even a popular book titled Predictably Irrational implying that we are indeed irrational.

Let's step back. When is a decision "irrational"? I believe that irrational decisions occur when decisions go against or are counter to logic and reasoning. But then that begs the question, what do we mean by 'logical'; and more important, is logic just a natural state or does it come from a particular perspective?

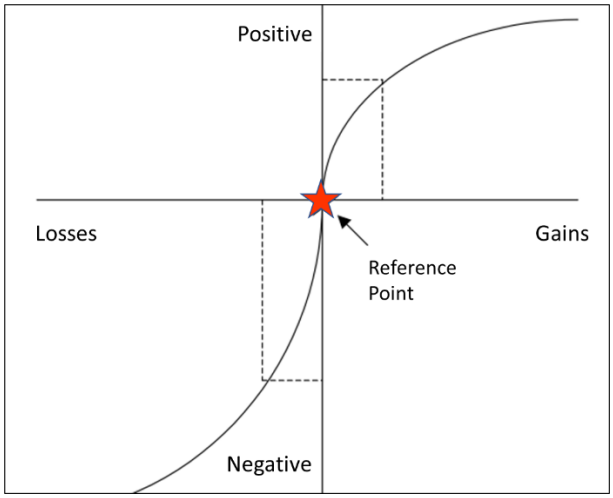
Daniel Kahneman, who won the Nobel Prize in Economics, found that cognitive biases impede our choices and decisions. Economic theory assumes that all our rational choices and decisions should be maximising our wealth (which economists describe as 'utility'). For example, many consider the act of buying equities when the stock market is peaking and then selling them when the market declines sharply as irrational behaviour. Yet, from an individual's perspective, is that an irrational decision?

LOSS AVERSION

Loss aversion, the tendency to prefer avoiding losses to acquiring equivalent gains, is a very powerful bias and can sometimes lead to irrational behaviour. In countless studies of human behaviour, of which I see almost without fail in the Mitigating Bias course exercises, people will almost always be relatively conservative seeking a gain but will make significant efforts to avoid an equivalent loss. To check that you have this bias, think back at some economic decision you have made, and how you felt when you made a gain and when you made a loss; I will expect you more vividly remember the loss than the gain (and the associated feelings you had), even if the gain was a greater amount than the loss!

Kahneman and Tversky (1979) suggested that losses lead to a more extreme emotional response than gains, where we value losses at about 2 to 3 times than gains of the same value. In other words, the response to positive and negative events is notably asymmetric, where the subjective 'pain' is significantly greater than the subjective 'pleasure'. For example, you will have a stronger negative feeling when you unexpectedly lose $100 compared to the positive feeling associated with a $100 gain. Marketing efforts use this to their advantage, manipulating how the situation is framed (note, the *framing* bias will be considered in a later blog article).

The following figure (adapted from Bertrand Jayles, 2017) nicely shows the dichotomy between gains and losses, and associated positive and negative feelings, respectively.



The X-axis represents the gains and losses; and the Y-axis signifies the positive or negative feelings one has given a certain gain or loss. Two things are significant. One, as Kahneman and Tversky suggest, the pain of a loss is stronger than the equivalent gain (note the lower rectangle is longer than the upper rectangle, but each have the same width). Second, the positive feelings toward a gain diminish as the gains increase, whilst the pain continues to increase (yet at a certain point, that too levels off). Rational economic theory, though, states that it should be a straight line with an equal slope through the reference point; and hence, the deviation of the curved line from the straight diagonal line, called a utility curve, is a measure of how inconsistent we are.

The graph shows why people tend to be 'risk averse' when they are deciding among potential gains or positive outcomes (i.e., one would rather have a sure thing than take a gamble for added gains) as the satisfaction of the additional gain is relatively less. Yet they are 'risk seeking' to avoid losses (i.e., one would rather gamble to avoid a loss rather than take a sure loss) as the first loss pain is relatively much greater than any subsequent losses.

YOU ARE AN IRRATIONAL PERSON? PERHAPS NOT!

In an earlier blog we touched on the evolutionary basis of cognitive biases and how they actually may be a design *feature* rather than *flaw*. Let's take a look at these ideas in the context of loss aversion. As humans, we are designed to avoid risk as a good strategy for our survival. Yes, it is important to have enough food to sustain us and we will work hard to produce this; but if we lose our source of food (for example, all our crops fail or the village nearby steals our food), we will be extremely agitated.

Let me use a simple realistic evolutionary example. Say you need two bread loaves to survive. You start with one loaf. I then give you a second loaf. You will certainly feel 'pleasure' with this gain. I then give you another loaf. As I continue giving you loaves, you probably will get to a point where any extra loaves really do not make a whole lot of difference in your feeling (assuming you do not sell or give them away to those in need). I think this is why economists suggest there is an optimum amount of wealth, and any additional amount levels off in terms of your satisfaction.

Now, let's explore the loss. You have one loaf, and I take it away. You will certainly feel pain. I then dictate you owe me another loaf, and your pain becomes severe. As I continue this, your pain level continues rising in significance. I suppose at a certain point you just don't care anymore, and hence the levelling off. Simply put, a loss of food could cause death, while a gain of food would not!

Standing back from this example, is loss aversion irrational? I would suggest not, as you are programmed to avoid loss preferentially over seeking a gain for your survival.

IRRATIONAL? YES, BUT IT IS COMPLEX

Yes there are occasions where I think we can clearly identify irrational behaviours due to judgments and decisions impacted by cognitive biases. There are countless examples where individuals make poor decisions in the E&P industry due to loss aversion. For example,

- Avoiding countries with higher-than-average political risk (when the goal is to grow your resource base)
- Not drilling wells with a low chance of success (when those projects are associated with larger resources)
- Drilling appraisal wells to confirm your current understanding (rather than reducing the uncertainty of your current view to understand the best development plan)
- Establishing consistent production (rather than trying to maximise production)

However, it is not as clear cut when we factor in our goals and objectives. Because of our evolution, many of our actions and decisions may in fact be rational in another context.

Hence, I do not subscribe to the hypothesis that humans are just plain irrational creatures in all of their actions! Rather, we need to understand when this irrationality may lead to sub-optimal decisions, and work to mitigate against such biases as *loss aversion*; these are addressed in more detail in the Mitigating Bias course.

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UNTIL NEXT TIME

Next time we will explore the *overconfidence* bias, one that is endemic in the oil and gas industry and perhaps best describes why our predictions often fail to meet outcomes.

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Marc Bond
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BIAS

#12 Overconfidence

Perhaps no challenge is more prevalent in interpretation, judgment, and decision-making and more potentially disastrous than the *overconfidence* bias. Literature and observations by myself and R&A colleagues suggest it is the bias that most contributes to poor predictions. As my colleague Pete Rose has succinctly said to indicate this bias: "Often in error, seldom in doubt"!

WHAT IS IT AND HOW DOES IT WORK

The *overconfidence* bias is our tendency to overestimate the accuracy or likelihood of our own interpretations, judgments, predictions, or abilities.

Overconfidence tends to be an innate character in us and serves an advantageous purpose. For example, if you are going to a job interview, projecting abundant confidence in your abilities and talents may help portray you as a highly competent candidate for the position. Overconfidence can also give people the will to succeed, providing them with both initiative and drive to complete difficult tasks or take sizeable risks.

When making judgments under uncertainty people combine both strength (i.e., outcomes, observed results from data) and weight of the evidence (i.e., sample size, reliability, or credibility of data), using both components to help them finalise decisions. However, we usually place a much greater emphasis on the strength of the evidence with little consideration of the weight, often ignoring rules of probability and statistics.

For example, suppose we wish to evaluate evidence for the hypothesis that a coin is biased in favour of heads over tails. When we assess the coin tosses, the proportion of the outcomes (e.g., the number of heads flipped) our trials will reflect the strength of the evidence. For example, if we flip 5 heads in a row, we see that as strong evidence that the coin is biased towards heads). However, when making this judgment, we tend to ignore or down-weight the number of flips we have made, which represents the weight of the evidence.

We tend not to consider that confidence may not convey accuracy, and in fact there is often a poor correlation between the two. We think that if we are confident about something, then there is a good chance it will happen. Unfortunately, people's confidence ratings are pretty much unrelated to their accuracy. Note that confidence is subjective whereas accuracy is objective. One study (Oskamp, 1965) shows that individuals confidence increased with the amount of information they were provided, but their accuracy did not!

Many of the other cognitive biases that we have discussed, such as *availability*, *anchoring*, *confirmation*, and *information*, will contribute to and exacerbate the *overconfidence* bias as they tend to emphasise the strength of the evidence and give the appearance of increased confidence.

POOR PREDICTIONS OF UNCERTAINTY

We systematically overestimate our knowledge and our ability to predict. There is often a significant difference between what people *actually* know and what they *think* they know.

Narrow ranges of predicted outcomes are a symptom of the *overconfidence* bias, particularly when uncertainty is high (i.e., weight and knowledge are low).

Studies and practical trials show that when people are asked to provide a range of answers to a series of general knowledge questions, with the requirement that they be 80% confident that the correct answer will fall within their predicted range, their accuracy is very poor. Generally, I get 20-40% correct answers (rather than the expected 80%) when I do this exercise in the Mitigating Bias course, and this has been repeated in many other studies. Even those that are aware of this exercise and have done it before still do not perform well.

Why are the predicted ranges always too narrow? Because people think they know the answer, and this will likely be compounded by other cognitive biases which will tend to bound their answers.

IMPACT ON OIL AND GAS INDUSTRY

The *overconfidence* bias is endemic in the oil and gas industry, influencing our interpretations, estimations, assumptions, and decision-making. Welsh et al (2007) undertook an assessment that shows as our overconfidence increases, we substantially erode value.

There are countless examples where the *overconfidence* bias is widespread within our industry. To name just a few:

- Strong opinion of prospect or opportunity
- Resource estimation (particularly minimum) is too high, with a narrow range
- Chance of Geologic or Commercial Success assessment is too high
- Justification for data interpretation too confident
- Underestimated costs and time for project completion*
- Portfolio outcome predictions
- Production targets are too high

Particularly in areas of high uncertainty, experts tend to be more overconfident than generalists as they tend to believe their model and observed results rather than the weight of the evidence. Experts also do not get fast and accurate feedback (or sometimes no feedback at all!) of their predictions and thus can be poorly calibrated. This can exacerbate an assessment and lead to overconfidence.

*An aspect of the *overconfidence* bias is the Planning Fallacy, which we will address in a future blog article.

OVERCONFIDENCE VERSUS OPTIMISM

One area I want to touch upon is the difference between 'overconfidence' and 'optimism' as they are two different concepts. The terms are often incorrectly used interchangeably, much like the terms risk and chance. We have defined overconfidence above; optimism is a belief that a positive outcome will occur. This is when the *optimism* bias, in which people are over-optimistic and underestimate the possibility of undesirable outcomes, comes into play. Although both are a universal human tendency, the *overconfidence* bias has the greater negative impact on our assessments and decisions.

In our industry, particularly exploration, it is essential to be optimistic given the high failure rate of opportunities; it would be difficult to work in this business if one were always pessimistic. For example, geoscientists working in a frontier basin trying to develop a new play would struggle if they approached the opportunity negatively.

However, being optimistic does not necessarily imply that one is overconfident. For example, the failure rate for the restaurant business is about 60% in the first year and over 80% after three years (Bellini, 2016). To open a new restaurant, one clearly needs to be optimistic. Yet, if they approach the business with open eyes and understand the base rate for success, they are not being overconfident.

An example in exploration would be when the geoscientist assesses the resources of a prospect with an appropriate range yet is optimistic based upon their evaluation that the higher end of the resource prediction has a decent possibility. In this evaluation they are not overconfident as they have described the opportunity with a wide range of possibilities, but they are optimistic of a positive outcome.

A note of caution, though. Combining both the *overconfidence* and *optimistic* biases (i.e., narrow predicted range leading to resource overestimation) is perhaps the deadliest combination. Beware!

WHAT CAN I DO

Given the *overconfidence* bias prevalence in the oil and gas industry, it is essential to be aware of your natural tendency to be overconfident. One of the successful mitigation strategies is to consider several different scenarios and ensure that your predictions have a sufficiently wide range of possible outcomes. When making an assessment, stop and consider why your judgments may be wrong. Regularly gather feedback on your estimates (performance tracking) and calibrate your predictions and confidence with the actual outcomes. Then capture and apply any learnings to help improve your future performance. This is one of the reasons why weather forecasters tend to be particularly good in the predictions – they get almost immediate feedback in their forecasts and in turn update their models.

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UNTIL NEXT TIME

The next article in this series will explore the notion of framing and how the *framing* bias can influence decisions.

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BIAS

#13 Framing

What type of yoghurt would you prefer to purchase? One that is 90% Fat-Free or one that has 10% Fat? Yes, you all know they are the same; but I imagine the former resonated more with you. Why? I framed the decision! Being influenced by how an opportunity is described is the crux of the *framing* bias.

WHAT DO WE MEAN BY FRAMING?

The way facts, information, options, or recommendations are presented influences people to make different judgments or decisions. That sequencing or packaging of information (often in a manipulative way) is referred to as framing. This is most relevant when something is presented in a manner to convey a positive state or a gain, or alternatively to accentuate a negative, a loss, or a threat. Framing is an example that shows how context can influence an outcome (much like how the *anchoring* bias creates a framework with the initial 'anchor' – see earlier blog article #10).

The 'frame' primes the recipient to view the presentation in a more favourable manner. It is not easy for us to take in all the perspectives, factors, and information related to a decision. Our tendency is to be passive and not engage in reflective thinking (see earlier blog article #2) and rather, be led along by the presenter. This helps the host convince someone or get them to agree with their position. Here is a classic example:

> *You really want to go to this new Italian restaurant. Your partner is not so convinced and is leaning more to the standard pub fare. So, you are talking with your partner about where to go for dinner. You could easily say, "Where would you like to go for dinner?" Or perhaps, "What strikes your fancy? Italian or pub?" Or, "Why not this time go for the pub, and we can check out the Italian later?". But no; rather you say, "I just read some fantastic reviews on this new Italian restaurant. The reviews rave on about how good the food and service are. Shall we go there Friday?" You have just framed the decision!*

Retailers realised this when they were trying to decide the best way to separate credit card versus cash users. Given credit card companies charge a service fee to the retailer for using the card, companies tried to see if they could recoup these costs from the consumer. Was it better to have a sign saying "2% Discount for paying cash or "2% Service charge for paying by credit card"? Both are the same yet are framed very differently. The first is framed as a savings if one pays cash; the second as a loss if one uses credit card. Retailers decided the former was the better choice as people much prefer a gain over a loss.

IT'S NOT JUST ABOUT MINOR DECISIONS!

Politicians and medical professionals use framing a lot. For example, a politician will usually frame a proposal in a positive light, ignoring any negative consequences related to their proposal. A medical professional will usually frame the proposed treatment in a positive manner, talking about the benefits

in a statistically positive way (e.g., one has a 90% chance of survival with this approach vs. a 10% chance of death). Their 'frame' will influence your views and decisions that can often have significant consequences.

We all frame, sometimes consciously, sometimes unconsciously. We may not consciously think about how we frame questions and statements, but we intuitively grasp the importance of framing. Think of a presentation you are giving to management of your work and recommendations. You will be framing the context, the message, and the conclusions simply in how you order your slides, even if you are unaware, you are doing that. Usually it is with the opportunity being presented positively. About everything you hear or read has been framed in some manner.

In the oil & gas industry the *framing* bias is widespread, and often can lead to poor decisions by the decision-makers. For example, the presenter may emphasise the project upsides and understate the downsides. Or they may only compare their opportunity to a favourable analogue. Perhaps if your company performs spectacularly poorly, that can be framed as an opportunity and a learning experience. When presenting data, it can be manipulated to show positive results (e.g., by selecting a specific time period, one can show a successful exploration portfolio).

One of my favourite examples was once when I was assuring a project the team included the classic 'show' seismic line in the PowerPoint presentation! Yet when asked to see some more seismic, even ones that are nearby, the presenter would look at me sheepishly; invariably the lines did not look nearly as enticing!

LOSS AVERSION AND FRAMING

In an earlier blog article #11 we talked about Loss Aversion. The *framing* bias can feed off this by framing something that is identical as a gain rather than a loss (e.g., which would you prefer, a diagnosis that says you have a 90% chance of surviving or one that says you have a 10% chance of dying? The former, as noted above, is framed positively, the latter negatively). The credit card example described above is also a good example of how framing can affect decisions. This can be used to manipulate decision-makers by focusing on the elements that suggest attainable success or value. For example, in exploration geologists will consider several geologic elements when assessing a prospect's chance of success. Rather than presenting in a neutral manner and discussing both the positive and negative considerations, one may just talk about the positives.

WHY IS THIS IMPORTANT?

If we are trying to help decision makers decide (e.g., whether or not to drill an exploration prospect), we should present our assessment in a neutral manner, expressing both the positives and negatives. For example, when discussing the chance of success and individual chance elements, focus on both the positives (e.g., if assigning 70% probability for source) and the negatives (e.g., why you considered a 30% probability for failure for source).

We should be upfront with not only the potential, but also the risks and concerns. Frame the presentation in such a manner that it is an honest assessment, showing both the pros and cons. This will then give the decision-makers a full understanding of the opportunity and help them make a more informed decision.

When presented with a recommendation, always be on your guard if it is being framed in a particular manner. Think about how it is framed, and if there appears to be a bias, re-frame the recommendation. For example, if it is framed in a positive manner or a gain, then frame it in a negative manner or a loss. Also, seek out different perspectives that might help you re-frame the problem.

Finally, an independent party not involved in the decision can provide a wider perspective of the opportunity and decision. In the hydrocarbon industry that role can be filled by assurance teams.

The *framing* bias is one of the several cognitive biases addressed in the Mitigating Bias course.

UNTIL NEXT TIME

The next article in the series will explore the *ambiguity* bias and how we often struggle with characterising uncertainty.

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BIAS

#14 Ambiguity

I've got a game for you, and you could win $1000! Imagine you have two jars before you and you cannot see their contents. Jar A has 50 red beans and 50 black beans. Jar B has 100 beans, but you do not know the proportion of red and black beans. If you reach into one of the jars and pick a red bean, you will win $1000; and if you pull out a black bean, you receive nothing. Which would be your preference, Jar A or Jar B?

AMBIGUITY ….. NOT A CLUE

In the *ambiguity* bias, people avoid options in which the chance of a favourable outcome is uncertain or ambiguous. Their bias is exacerbated by missing or limited information, because it makes the choice seem riskier. Instead, many people show a preference for options where there is a known probability of a favourable outcome. How might this play out? I imagine that most of you chose Jar A. Why? Because it has a known probability; compared with Jar B where the probability is completely unknown, as it could have 50 red beans or 99 red beans or 1 red bean.

Ambiguity is more about uncertainty than chance. For example, there is a chance porosity will be too low and that would constitute a reservoir failure. The ambiguity is that I do not know the exact porosity of my reservoir and given the uncertainty I should produce a range as my prediction. People often mix up the two terms, chance and uncertainty. Many also interchange the terms chance and risk (*that's a blog article for another day!*).

Because most of us struggle to characterise uncertainty, we try to avoid it where we can. We will instead seek opportunities where the probability is better defined or collect more data before making a decision. This is known as the Ellsberg Paradox, named after Daniel Ellsberg who popularised the concept in 1961 (later famous for leaking to the press the top-secret Pentagon Papers).

Even if data or probability support choosing the more unknown quantity, people will often prefer the known option. This prevents us from giving equal consideration to two viable options. Simply, people dislike uncertainty, and the *ambiguity* bias is a demonstration of this trait.

The *ambiguity* bias is similar to the concept of risk aversion (see earlier blog article #11) and is distinguished by how much information one has. Risk aversion is often seen when we know the probability and value of both options. We often tend to choose the option with a higher probability of success but might have a lower payoff (or one that might avoid a loss). In contrast, the *ambiguity* bias is where you know the probability of one outcome but not the other and gravitate to choosing the option with the known probability.

Let's consider a modern example of this bias. A consumer seeks to make a purchase from an online retailer. The individual is faced with two similar products: one with many reviews averaging 3.0 out of 4.0 stars, and one that has not been rated yet. The tendency will be to buy the rated product. Even

though the rated product has a mediocre rating, we feel more secure purchasing the known item. However, we may be missing out on a phenomenal product.

Often, we seek additional information, even if it is not relevant or does not particularly add much to the decision. More is not necessarily better!

The *ambiguity* bias is related to both the *information* (i.e., data and probability) and *availability* (i.e., your experience) biases; see Blogs #2, #3, and #4.

AMBIGUITY BIAS INFLUENCES CAN BE CONSIDERABLE

The *ambiguity* bias has a wide reach. It can influence our small choices (e.g., which television to buy), but can also have an impact on decision-making on a much larger scale.

We see the ambiguity bias in financial decisions. For example, people will tend to choose a fixed-rate mortgage, rather than a variable rate. They might invest in low risk, low return investments such as bonds, instead of more volatile investments such as equities. The former choices have a known return and are considered 'safe'; the latter are much less predictable and thus considered riskier. In both cases the more uncertain options may yield better returns over the long (and uncertain) term.

People and business often struggle with change. Even in cultures in which change is viewed positively, people are reticent to make a change. In business, this can be devastating. The *ambiguity* bias is one reason governments and companies do not change policies, even if the current system is far from optimal ("better the devil you know"!). For example, consider a company whose sales are declining. Ten years ago, they were a leader in their industry, but now they are not performing well. Senior management decided they needed to tackle the problem, so they go out to tender with two business consultancy firms.

- Consultancy firm #1 recommends a series of rigorous initiatives and improvements on the current business practices, which they show will improve sales.
- Consultancy firm #2 suggests that their current business model is no longer appropriate in the current environment and recommend a completely different model, which they show will improve sales.

The company must decide which option to execute. The *ambiguity* bias will lead management to choose consultancy firm #1 as their proposal has the appearance of certain results building upon known business practices. A couple of companies that should have chosen consultancy firm #2 include Blockbuster and Kodak. Both missed how the advent of digital media (streaming movies for Blockbuster, digital images for Kodak) would dramatically change business models, allowing other companies to replace them in the marketplace.

EXAMPLES IN THE HYDROCARBON INDUSTRY

We can find many instances of the ambiguity bias in the oil and gas industry. For example,

- Choosing to explore in a known, proven basin vs. a frontier area with unknown potential
- Preferentially drilling a well where you understand the petroleum system and the probability of 'success' over a well where there is uncertainty about some of the chance elements (e.g., at 50%), even if the overall chance of success for both is the same
- Appraising a more updip location in order to improve your success probability rather than seeking a more downdip location which would tell you more about the overall potential but has greater uncertainty (be sure to check out the latest article on down dip chance and size calculations by Mark Schneider and David Cook)
- Preferring areas with a greater amount of data

- Equating lack of or poor-quality data with low chance of success
- Facilities are often sized smaller than they could be, ultimately due to concerns about the uncertainty of the underlying resource (e.g., volumes or the ability to obtain the higher rates needed to fill a larger facility)

EMBRACE UNCERTAINTY

Uncertainty is a state of the universe, so learn to accept ambiguity and work with it.

Ensure you are informed and seek out more information if it will help you make a better decision. Be open to new concepts and ideas. Embrace change and tolerate uncertainty, even if feels uncomfortable. For the ambiguous option, consider not only the negatives, but also why it could be a better choice. Understand the difference between risk, chance, and uncertainty.

Often when making decisions under conditions of uncertainty, one technique is to frame the unknown action against the one that you are familiar with. For example, a new play by definition will have a great deal of uncertainty, so one could compare attributes of the new play with those of other successful new play entries. You can also use statistics to support your decision. For example, in deciding whether to invest in bonds or stocks, you can show the differences in the long-term performance of both options and not just the immediate payoff.

As a final word, remember that "the absence of evidence is not evidence of absence"! (quote attributed to cosmologist Martin Rees and popularised by Carl Sagan).

UNTIL NEXT TIME

The next article in the series will explore an aspect of the *overconfidence* bias known as the *planning fallacy* and why so often our plans usually do not turn out as expected.

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BIAS

#15 Planning Fallacy

We talked earlier about the *overconfidence* bias, an endemic problem in all businesses including the hydrocarbon industry. A consequence of that bias is the *planning fallacy* (see earlier blog article #12).

PLANNING

How often do you run into any of these situations in your daily life? It takes 15 minutes driving time to get to your destination. You walk out of the house 13 minutes before you are due to arrive, and so you are already a few minutes late. On the way, you run into traffic. Or you tell your colleague "Just give me 5 minutes and I'll get back to you", and the phone rings, delaying your response. Or the email that you expect to send out in a couple of minutes turns out to be much more complex than originally thought, and you are still working on it 30 minutes later.

We all make plans. For some, they are quite rigorous, preparing checklists with tasks and dates for completion; others are more subjective in their approach. In either case, we are often surprised how things take longer than expected. Unexpected events happen that we did not foresee derail our 'best laid plans'. Even professionals, who we expect to know what they are doing (such as a contractor remodeling your house), have delays and their projects are usually not completed as per the initial expectation. We often just shrug our shoulders and think that is just the way it is.

Let's look at an example of remodeling a room in a house. I imagine the contractor has a very good idea how long individual tasks take. But what about the external factors such as supply problems, delivery delays, workers' absences due to illness, weather, hazardous conditions … the list is pretty much endless. Then there are the internal factors such as running into an unanticipated problem (e.g., more complications). Usually, individuals chalk this up to events out of their control and don't blame their poor planning. However, contractors have seen these problems before and know that something inevitable will happen that causes the project to be delayed and costs go up. Yet, they don't include this in their planning.

What's going on?

PLANNING FALLACY ….. WE THINK WE'VE GOT IT COVERED!

The *planning fallacy* refers to one's tendency to underestimate the time for completion, cost, and/or risks associated with projects or tasks. This is known as a 'fallacy', rather than a 'bias', as it implies that one's plans are really a mistaken perception of reality! People systematically underestimate costs, time for completion, and project risks.

My view is that plans do not take longer than originally predicted; rather, often one's plans are overly ambitious in the first place and thus likely to not meet the prediction.

Why do we get it wrong so often? The *planning fallacy* stems from three primary factors: (a) overconfidence and overoptimism; (b) considering only one case; and (c) the desire to complete the

task quickly and efficiently. Most project plans (cost and time) are overly ambitious. Even after experience that your plans almost never go as planned, you persist with the same endeavours ("experience is inevitable, learning is not", Paul Shoemaker). We anchor (see earlier blog article #10) ourselves to our original plan, and struggle to deviate.

We focus too much on the desired project outcomes and overlook the external influences. Unexpected events will invariably lead to either increased costs or time for completion, or both. In other words, I like to say, "Stuff happens".

When we focus on the forecast, we tend to look at the individual elements, and unique features of the tasks that go into the project plan and allow us to successfully complete the project. 'Planning' for most people means to develop a series of specific steps that lead from beginning to a successful completion of the project. We may have a good understanding of the time and cost for each element, so we just add all the elements up, and now have the plan.

However, we generally fail to appreciate the many ways in which the future may unfold, including external influences, usually not in our control. Given the vast number of potential complications, people will usually encounter unexpected (or unplanned for) problems, delays, and interruptions. We do not consider that some of the tasks are done in series, and if there is one delay then the whole project gets delayed. We will also tend to be overconfident in our abilities, thinking we know more and will do better, thus predicting an overly optimistic forecast. When people focus narrowly on a plan for successful task completion, they neglect other sources of information—such as past completion times, competing priorities, and factors that may delay their progress—that could lead to more realistic predictions. Conducting systematic lookbacks on project performance would be a good technique to correct this behaviour.

Even if our experience is that our project almost never meets the predicted costs and schedule, we do not seem to use this knowledge. Researchers suggest that this is because we have a future orientation which prevents us from looking backwards. Another explanation is that we fail to incorporate this information into our predictions because we do not think it is relevant to our current plan.

EXAMPLES OF THE PLANNING FALLACY

In daily life, effective plans allow us to coordinate schedules with those of friends, family members, and co-workers. Usually, we get by when our plans do not materialise as expected, but often they can have serious economic, personal, and social costs. Governments and businesses all spend a considerable amount of time, money, and effort trying to forecast how long projects will take to complete. Underestimating project completion times and costs can have considerable implications.

The literature on this topic is littered with spectacular examples of project planning failures (e.g., building the Sydney Opera House and the Concorde).

It is not just mega-projects (see Merrow, 2012 for an excellent discussion on upstream oil and gas mega-projects poor track record) that fail to meet the planned schedule, but also 'small' projects such as drilling an exploration well, undertaking an appraisal programme, bringing a field online with production, or the acquisition of 3D seismic data. Usually these all end up over projected time for competition and/or cost.

I can share a few experiences where I could not believe what planners were doing. One group put together a probabilistic model of each element of the plan (so far, so good) and then decided to take the P40 (i.e., optimistic case) of the plan for each element of the plan, as they felt confident in their abilities (you do the math!). In another example, a well engineer also did probabilistic modelling (also

good) but decided they will achieve a 'stretch target', and thus their expected base case proposal for cost and drilling of the well was the P30! Another team had a hard deadline and therefore 'fit' all of the aspects required to carry out the project to completion, and then proceeded to regard this as the most likely plan!

MITIGATIONS

As noted above, the problem is less about projects not going according to plan, but rather that the plans are overly optimistic and simplistic. The Mitigating Bias, Blindness, and Illusion in E&P Decision Making course discusses in details mitigation techniques. For example, some strategies you can use to mitigate the *planning fallacy* include:

- Shift the focus from the internal aspects of the plan to consider external influences more fully
- When looking at the individual elements of a plan, break them into smaller sub-components as this may help you find issues or things that could go wrong
- Look at completion schedule and costs for comparable projects, and consider this a base rate
- Based on the above, ensure to include a buffer time and costs for unexpected events
    - You may not be able to identify them in advance, but they surely will happen!
- Carry out a probabilistic assessment of the plan, just as one would do when estimating hydrocarbon resources.
- Consider alternative scenarios, especially considering unfortunate but realistic outcomes
- Include review points in the plan where you can re-evaluate as the project progresses, rather than waiting until it is too late.
- Seek outside assurance of your prediction from people not directly involved in the project
    - Studies have shown that when people make predictions about others' tasks, rather than their own, they are less prone to underestimate completion times and can spot deficiencies in the proposed plan
- Based on lookbacks of project performance, consider the addition of contingency costs (and time) to estimates (e.g., if a review of several recent projects, regardless of size, indicates cost estimates average 20% below actuals, add 20% to the cost for future estimates)
- Conduct root-cause analysis for all projects where actuals exceed estimates by more than 10 to 20%, looking for similar root causes among projects and then develop methods to avoid in the future

Finally, avoid the motivational bias (see earlier blog article #7). Even if you have pressure (real or perceived) to put together an optimistic plan, don't! Instead, present your management with a realistic schedule using the mitigations described above. If you are faced with the requirement to meet an ambitious target, then present mitigations (e.g., more people to work project) that will give you a better chance to meet your target. This will cost more money but will help you meet target.

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UNTIL NEXT TIME

The next article in the series will address bias from an engineer's perspective by interviewing two expert Rose & Associates engineers, Mark Schneider and Doug Weaver.

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Marc Bond
Rose & Associates

BIAS

#16 Engineers

Although I am an experienced geoscientist and assurance expert, I succumb to the biases outlined in the earlier articles in this blog series more often than I'd like to admit. When I started my career, I was told by a well-meaning individual, "You geologists are always overoptimistic and overconfident. We engineers are the realists at the party." Is this true? Are engineers less prone to bias? I thought I would reach out to two of my engineer colleagues, Mark Schneider and Doug Weaver, to get their perspectives.

Mark is a Partner at Rose & Associates with 40 years of diverse industry experience. He is a reservoir engineer who has spent over half of his career trying to improve uncertainty characterization and reduce the impact of biases in evaluations. He has been a member of both exploration and development assurance teams at the corporate level. He lives in Jakarta and coordinates R&A's business in Southeast Asia

Doug is a Partner at Rose & Associates with 43 years of diverse industry experience. He is a petroleum engineer, having spent over half of his career evaluating the resource characterization and economic value of exploration and development opportunities. He has been a member of a corporate level exploration assurance team. Doug lives in Houston, working with R&A clients headquartered in North and South America.

INTERVIEW

Marc: Mark and Doug, welcome to my Understanding and Overcoming Bias blog. I appreciate you taking the time to give our readers some of your insights on engineers and bias.

1. **Marc:** Let's get straight to the point, are engineers biased?

   Mark: *First, thank you for inviting me to give an engineer's perspective to your bias blog. When you look at the large body of literature plus my personal experiences as an instructor and consultant, and add the experiences of my colleagues at Rose & Associates, the evidence overwhelmingly concludes that we are all biased to some degree, including all engineers. That is why the R&A course you helped develop and your bias blog are so important.*

   Doug: *Sure, we all are. As with any of us, our biases are just a function of our background and experiences.*

2. **Marc:** Ok, no surprise. So, do you see the biases manifest themselves differently from exploration geoscientists?

   Mark: *You might be expecting me to say yes, but I am going to answer no. I believe the biases that manifest themselves the most often and with the greatest impact in subsurface evaluations are the same for geoscientists and engineers. These biases would include*

anchoring, availability, confirmation, and overconfidence, among others. What is different is that exploration geoscientists are dealing with a lot more uncertainty in assessing resources and chance of success for an exploration prospect than an engineer or development geologist is dealing with for development planning and production operations.

Doug: *I'm sure they do. Engineers have been trained to evaluate projects quantitatively, geologists qualitatively. (Sorry I know I'm generalizing a great deal). Both are prone to bias, maybe with different routes to get there, but bias, nonetheless.*

3. **Marc:** Do you consider that geoscientists are biased to the optimistic?

   Mark: *With regards to exploration resource estimation, the literature and experience I mentioned in my response to your first question suggests that geoscientists are optimistic. But remember, companies applying best practices will have an engineer on their exploration teams, so he must share some of that biased optimism too. And not all need be lost, with performance tracking and applying mitigation strategies, the bias can be minimized.*

   Doug: *No. If you discuss the quantification of a variable with a development geologist and an exploration geologist, you may get quite different answers and approaches. So, I wouldn't characterize this as engineer vs. geologist; rather explorationist vs. non-explorationist. Recognize that historically, many explorationists have been trained to push big numbers into their prospect evaluations. This creates a motivational bias – "If everyone's doing this, I better do it as well or my wells will never get drilled". This is one of the many reasons' assurance is critical to evaluation consistency.*

4. **Marc:** If so, does this influence the bias to the conservative for engineers?

   Mark: *From the wording of your question, it sounds like you are asking if engineers are intentionally biased to the conservative to offset their perceived optimistic bias in geoscientists. This might be true for some engineers, but I do not think it is true overall. In fact, I think the evidence shows that engineers are biased to the optimistic too. Referring to the literature studies and my own experience again, most large development projects are shown to have significantly overspent budget, come on stream much later than planned, and with initial production estimates larger than actually achieved. Looks like engineers are not exempt from being optimistic too.*

   I'd like to address the myth of all optimistic geoscientists and all conservative engineers further. I believe this perception began when geoscientists saw their resources estimates slashed when the engineers made initial reserves bookings. It might help with an example. Suppose an exploration team, after initial appraisal of a significant discovery, hands it over to the development engineers with Mean EUR of 302 MMBO. The engineers book Proved reserves of 100 MMBO and the geoscientists scream out loud that their discovery got smaller. But what has actually happened? The exploration team's post-appraisal EUR evaluation was P90 = 100 MMBO and P10 = 600 MMBO. The engineers accepted the post-appraisal EUR evaluation with no changes. However, they followed SPE PRMS guidelines and the reporting regulations of the country. So, the initial reserves booking was based on P90 = 100 MMBO for Proved reserves, P50 = 245 MMBO for Proved + Probable reserves, and the P10 = 600 MMBO for Proved + Probable + Possible reserves. The implied Mean EUR is 308 MMBO, which is a little more than the exploration team's estimate. Maybe your geoscience audience will take it a little easier on their engineers next time they book reserves for a new discovery. If there is no bias in the post-appraisal estimate, then the initial Proved reserves booked will increase about 90% of the time.

Doug: *You're suggesting engineers are trying to compensate for geologic optimism. If we assume geologists control inputs such as pay and area, and engineers control inputs traditionally in the engineer's domain, it's not much of an issue, pay and area drive the vast majority of prospect uncertainty and value. Years ago, I was responsible for the physical generation of resource estimates for a major oil and gas company working in the Deepwater GOM. Knowing that explorationists try to push the high side in estimates, when I recognized this was happening, I would suggest an even bigger number. This snapped reality back into play.*

5. **Marc:** Who do you think better understands and embraces uncertainty - geoscientists, engineers or a combination working as a team?

   Mark: *I strongly believe an integrated multi-discipline team will perform better than discipline segregated teams; so, I select your option #3, a combination of geoscientists and engineers working as a team as the one who better understands and embraces uncertainty. Now if you were asking to compare the disciplines, I would say exploration geoscientists embrace uncertainty better because they are evaluating prospects with much of the direct evidence missing and must rely more on analogs and geologic models. This requires them to do probabilistic evaluations all the time with more uncertainty than even the engineers who embrace uncertainty, but already have constraining data reducing the remaining uncertainty that must be understood and characterized.*

   Doug: *Neither unless they've been trained in how to address the issue.*

6. Do you see any bias with deterministic models, an often-used approach by engineers?

   Mark: *Yes, deterministic models can have a lot of bias because it is basically not possible to choose the correct input value for all parameters to match the scenario being evaluated. A deterministic estimate is still prone to all the biases that are endemic in our industry. And without a probabilistic distribution, it is harder to do performance tracking and get better calibrated for future evaluations. So, I personally like to apply probabilistic evaluations to even mature producing fields.*

   Doug: *Deterministic models should be avoided when decisions are being made. We're using one value to represent a range of outcomes which isn't correct. They do have value in creating "comfort levels" in project evaluations. If I multiply a specific area by a specific net pay by a specific yield, I generate a specific resource. In other words, they can reduce the "black box" concerns many folks have when dealing with probabilistic models.*

7. **Marc:** What do you see as the biggest obstacle for engineers to overcome cognitive biases?

   Mark: *The biggest obstacles are not necessarily hard to implement. I think it starts with awareness that bias exists in your evaluations, then have a mitigation strategy for all the most common biases in our industry and any other biases you see in yourself, finally compare actual results to predictions for all your estimates to become better calibrated for the future.*

   Doug: *Again, same as everyone else, we need to recognize that biases exist, we all have them, and that acknowledging this doesn't mitigate them. We need to take active steps such as using data driven analysis and creating alternate solutions to drive bias out of our evaluations.*

8. **Marc:** Any final thoughts you would like to share?

> **Mark:** *Though perfection is unattainable, it is not necessary for good decision-making. A realistic goal is to use mitigation tools to minimize bias in individual evaluations and to achieve an overall unbiased position for the portfolio of your evaluations. Achieving this will help your company to deliver on its promises.*
>
> **Doug:** *Yes, addressing the downside is the biggest issue we face when evaluating uncertainty. While we're happy to describe how big something can be, we're reluctant to account for how small something can be. This can be true even when obvious answers glare at us from data. There seems to be an overconfidence bias that blocks our ability to correctly address the downside; or perhaps, the thought that chance will take care of the issue. Either way, this is the culprit that leads to the poor performance most companies have regarding prediction.*

Marc: Mark, Doug. Thank you for participating in this interview and sharing your thoughts.

UNTIL NEXT TIME

The next article in this series will address alternate scenarios, one of the major mitigating strategies for our biases that we so often struggle to implement.

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Marc Bond
Rose & Associates

BIAS

#17 Alternate Scenarios

Two of the best ways to mitigate biases is to consider alternate scenarios and multiple working hypotheses; yet technical teams often overlook these important processes. Why?

THE NORMAL EXCUSE

Interpreters often suggest lack of time and limited resources for why they do not consider alternative models. Certainly, one unfortunate aspect of the exploration process is that the technical work always gets squeezed for time. For example, seismic data needs to be acquired, commercial arrangements made, and management needs to make decisions, all of which delays interpretation. It is tough to work on the technical evaluation when you are waiting for necessary data. But does that preclude considering other models? Although there is some merit to this justification, it's still an excuse, masking a much deeper flaw. Could it be that our cognitive biases impede our ability to consider alternate scenarios? Let's explore.

MULTIPLE WORKING HYPOTHESES

When we consider alternate scenarios and models, we examine multiple working hypotheses; in other words, proposed explanations for a phenomenon we wish to study. A geologist, Thomas Chamberlin, first described the concept of multiple working hypotheses (Chamberlin, 1890).

Many of these hypotheses will be contradictory, so that some, if not all, will prove to be false. However, the development of multiple hypotheses prior to the research lets us avoid the trap of focusing on just one model and ensures we keep an open mind to the actual possibilities. It is important to realise that a phenomenon can be the result of several causes, and data and observations can support the feasibility of more than one model.

COGNITIVE BIAS REFRESHER

Let's step back and remind ourselves of the definitions of the Cognitive Biases we have discussed in this blog series; please check out the links below to each bias reviewed:

- Ambiguity – see *Blog Article #14*
- Anchoring - see *Blog Article #10*
- Availability - see *Bias Blog Article #2*
- Confirmation - see *Bias Blog Article #6*
- Framing – see *Bias Blog Article #13*
- Illusion of Knowledge – see *Bias Blog #8*
- Illusion of Objectivity – see *Bias Blog Article #8*
- Illusion of Potential - see *Bias Blog Article #8*
- Information - see *Bias Blog Articles #3 and #4*
- Planning Fallacy – see *Bias Blog Article #15*
- Overconfidence - see *Bias Blog Article #12*

- Motivational - see *Bias Blog Article #7*

BIASES INFLUENCE OUR BEHAVIOURS

Each bias covered in this series can adversely affect our interpretations, assessments, judgments, and decisions. They can also influence our behaviours, creating pitfalls that make it challenging to consider alternate scenarios and multiple working hypotheses.

- Illusion of Knowledge & Potential, and Overconfidence – leads us to believe we understand the model and fully incorporated all the data.
- Illusion of Objectivity – believe that we have objectively considered all possibilities.
- Anchoring – we are attached to one scenario or analogue.
- Ambiguity, Availability, Confirmation, and Information – can lead to us incorrectly assessing the impact of (i.e., overweight) new information on our model.
- Framing – an inclination to favourably present our preferred model.
- Motivational – we have a personal investment in developing the model.

These biases can enhance our tendency to incorporate our prior experiences as we interpret data, in turn making our models look more positive and probable. This then leads us to strongly favour a preferred model and reject others. We then may find ourselves in a vicious cycle where continued work and analysis further strengthens our belief in our model, making us overconfident that it is the correct one. This will in turn effect our judgments and decisions of the way forward.

Certainly we will want to mitigate the influence of each of these biases, which we go into great detail in the Mitigating Bias, Blindness and Illusion in E&P Decision Making course. To compliment these mitigations, you might consider implementing the following work strategy.

PROPOSED WORKFLOW TO CONSIDER ALTERNATIVE SCENARIOS

The five-step workflow can help ensure alternate scenarios are considered and evaluated: Range – Likelihood – Revise – Remove – Progress.

1) **Identify the full range of possible subsurface models that are supported by the data and interpretation and avoid arbitrarily dismissing any model.**
   - There may be a favoured model, perhaps one that was developed at the initial evaluation stage (this is known as a working hypothesis). Rather than only focusing on this model, teams should highlight other models that are viable and supported by the current data and knowledge. You will want to highlight all the assumptions and justifications for each scenario. Documentation of this step is critical, as it is often difficult to simultaneously keep track of multiple concepts. A Framing Session is a great way to address this step of the workflow (*please feel free to contact me for further information on how to hold a Framing Session)*. Partners are also an excellent source of alternative interpretations and models as their work will be independent of yours.

2) **Consider the likelihood of each scenario given your current data and understanding.**
   - You will now want a better insight into which scenarios are more likely given the data and will need to assign a probability of success to each. As we are much better at relative judgments rather than absolute, this will help you to make comparative judgments between the different scenarios and determine relative weightings on the likelihood of each. For each model, as you do with estimating a prospect chance of success, look at each component independently rather than taking a holistic view of the model. You will want to outline further work and data

required to progress your understanding of each model. Biases can make this step more challenging, so consider not only why a model may work but also why it may not.

3) **Given new data or information, revise the likelihood of each previously considered scenario.**
   - New data or information should help you to further understand the viability of the models. Discussing with other individuals, particularly with diverse experience, often makes a better analysis. Another Framing Session or Peer Review may be appropriate for this step.

4) **Remove any scenarios that are internally inconsistent, have clearly flawed assumptions, or low likelihood given the new evidence.**
   - Carefully consider your decision to remove any scenarios from further analysis. Whilst you need to reduce the number of models you will be working on given your time constraints, do not lightly dismiss any scenario. For example, there may be an erroneous tendency to remove a scenario that suggests limited potential (a common manifestation of the *illusion of potential* or *overconfidence* biases). This step is perhaps where team creativity will be at its peak. You should ensure documentation of your work, noting all the models you have considered and why, and your justifications for not moving forward with the models you rejected.

5) **Progress the remaining scenarios that are now most probable.**
   - By this step you will evaluate the remaining two or three scenarios. This is where you will outline the appropriate work programme to rigorously evaluate the model and the risk and uncertainty of each hypothesis and specific geologic elements (i.e., reservoir, source, and trap). Your further work and data should then help you focus on the most likely scenario/s. Many commercial prospect resource assessment software modules, such as ProjectRA, now permit probability weighted aggregation of models and can solve each model independently.

Reference Cited

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A special thanks to Henry Pettingill of Rose & Associates who provided suggestions to the proposed workflow.

UNTIL NEXT TIME

The next article in the series will explore an aspect of the *information* bias known as the *conjunction fallacy* and how this heuristic may contribute to people believing in conspiracy theories!

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Marc Bond
Rose & Associates

BIAS

#18 Conjunction Fallacy

Conspiracy Theories … most of us find them rather humorous, but also wonder why anyone believes in them. There are countless examples, and there are several psychological explanations of why people believe in them (see Douglas et al, 2017). Some famous examples include: Lee Harvey Oswald did not act alone in the assassination of President John Kennedy, 9/11 was a U.S. government plot, and British government agents killed Princess Diana, to name a few. Given my work with cognitive bias, I postulated that one explanation for some could be related to the *representative* heuristic (see earlier blog article #3), and more specifically the *conjunction fallacy*.

CONJUNCTION FALLACY

The *conjunction fallacy* is a specific error of reasoning under conditions of uncertainty whereby people overestimate the likelihood of co-occurring, ostensibly unrelated, events, which is a product of the *representative* heuristic. Simply, people use their intuition in perceiving that the two events together are more likely to occur than either event alone. Let's start with an easy one, which is more likely:

1. Tom has eyes
2. Tom has blue eyes

In this example, there is no narrative to explain; we all get the correct answer.

This *conjunction fallacy* was explored by Tversky and Kahneman (1983) with what they called the Linda problem. In their studies they found that over 50% of the participants in their studies fell prey to the *conjunction fallacy*.

Now, select which is more likely:

1. Tom has blue eyes
2. Tom has blue eyes and is Norwegian

The latter certainly sounds more plausible and more representative, as the majority (55%) of Norwegians have blue eyes. However, it must be far less frequent than option #1. Choosing option #2 is an example of the *conjunction fallacy*. This is a problem when listening to forecasters when they add detail to scenarios, perhaps inferring a linkage, making them more persuasive and believable, but less likely to come true.

We can observe the *conjunction fallacy* in the hydrocarbon industry where it manifests itself when there is a higher confidence in opportunities or options that are highly complex and involve many components that must come together for success. Some examples of the *conjunction fallacy* in E&P include:

- A prospect with several faults, initially requiring one to be open to charge but then all faults to be closed to seal
- Because our reservoir model suggests a turbidite, we infer that the porosity must be good.

- The presence of fractures suggest that they must be interconnected and will enhance productivity.

All of these examples are certainly viable possibilities, but not necessarily the likely ones.

CONSPIRACY THEORY

Conspiracy theories are an unverified and implausible allegation of conspiracy, usually claiming that outcomes are the result of abnormal and sinister events. A small handful of studies have looked at the role of reasoning biases and heuristics as an influence in believing in conspiracy theories (Brotherton and French, 2014). For example, one suggestion for why people believe in conspiracy theories is that simple explanations for large events (e.g., 9/11) cannot be enough, and rather there must be a proportional explanation (i.e., mundane events result from mundane causes; significant events require significant causes). In other words, this is an example of the *representative* heuristic. Another suggestion is that conspiracy theories explain seemingly random and inexplicable events (*information* bias).

Rogers et al (2011) suggest that people who strongly endorse conspiracy theories are particularly susceptible to the *conjunction fallacy*. The *conjunction fallacy* posits that people are more susceptible to believing untrue stories if they are more elaborate and specific. Taken together with their earlier research (Rogers et al, 2009), this provides further evidence that conspiracy theories, similar with other anomalous beliefs, are associated with reasoning biases and heuristics.

They found that conspiracy believers have a biased conception of randomness, according to which they believe coincidences are rarely mere chance occurrences. Rather, causal relationships are inferred, which make conjunctive events more representative to conspiracy believers and thus more plausible than singular events (Nestler, 2008 and Tversky & Kahneman, 1983).

As those that believe in conspiracy theories often hinge on the idea there is a deeper conspiratorial plot, this helps give plausibility to the conjunction of unrelated facts. Any information that may support the hypothesis is used to validate the theory and any counter arguments can be easily justified away by employing the *confirmation* bias (see earlier blog article #6). Of the biases we have discussed over the past months, these two biases – *confirmation* and *conjunction fallacy* – perhaps contribute most to entrenched views of individuals.

EXAMPLES OF CONSIPIRACY THEORIES

The internet is awash with conspiracy theories, many that are absurd (e.g., the Beatles never existed, the Earth is flat, or Barack Obama can control the weather). However, there are many that could appear to be plausible, and hence why some may believe them. For example:

- President Franklin Roosevelt knew about Japan's 1941 attack on Pearl Harbour in advance and allowed it to happen to bolster support for the US Congress to declare war on Germany
- The 1963 assassination of President John Kennedy was a plot by either Cuba, the CIA, or U.S. organised crime
- The 1969 moon landing never happened, but rather was staged by NASA to hide the fact that they were unable to achieve that goal set nine years earlier
- President George Bush orchestrated the 2001 Twin Towers attack as an excuse to declare the Administration's 'War On Terror'
- The pharmaceutical industry has mounted a cover-up of the causal link between vaccines and autism

- The COVID-19 pandemic was initiated by the government for ulterior motives

Each one of the above examples could have a believable outcome, with components of the theory having a plausible explanation. I would be interested in readers choosing any of the above theories or one of your own and using the Comments section to discuss how the *conjunction fallacy* may have contributed to people believing in your selected conspiracy theory.

IN SUMMARY

Is the *conjunction fallacy* the only reason to explain why people believe in conspiracy theories? Certainly not; however, there is evidence to suggest that cognitive biases play a part and the *conjunction fallacy* may help to explain the reasoning that leads people to believe in conspiracy theories.

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UNTIL NEXT TIME

Next time … we will wrap up our bias blog with a summary of the past year articles and the interrelationships between the biases that we have addressed.

Please visit our website to view other Rose & Associates blogs.

Stay safe and healthy.

Marc Bond
Rose & Associates

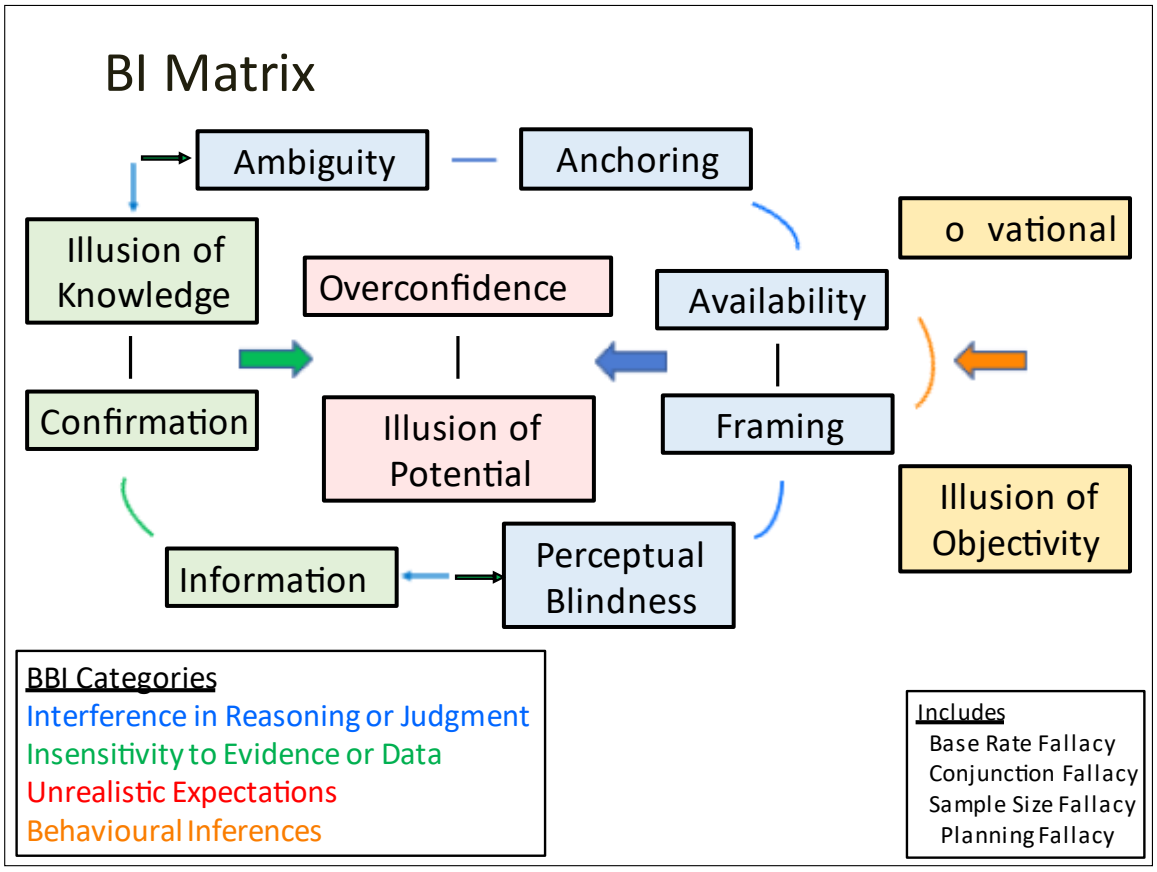
BIAS

#19 Conclusion & Summary

Time has flown by in the past year I've been writing this series on bias. I hope you have enjoyed it, and that it has increased your understanding of cognitive biases and how they influence our judgments and interpretations. On the one-year anniversary of the blog, it seems proper to hit the pause button and summarise.

Over the last 18 blogs we have explored several biases and related themes. I have compiled all the blogs into one location which you can freely access at the following link: Bias Blog. The set will take you through the many biases and how they impact us, and additionally – what I think distinguishes this series – suggested steps on how we can mitigate their impact.

Although we looked at several of the biases and illusions independently, commonalities and interrelationships that impact judgments and decisions exist between the biases and illusions. The following figure illustrates this interaction.



These cognitive pitfalls fit into four distinct categories:

- Interference in Reasoning or Judgments
- Insensitivity to Evidence or Data
- Unrealistic Expectations
- Behavioural Influences

Many of the cognitive biases and illusions result in unrealistic expectations, exhibited by *overconfidence* and *illusion of potential*. Overlaying all of these are the behavioural influences that can trigger many of the cognitive pitfalls.

Given that we cannot rid these biases from our lives, there is no magic bullet to reduce their impact. We all have them, and they serve a function. However, **awareness** of the biases − how they work, situations where they might have a negative impact, and how they can impede our decisions − is the first step. Unfortunately, awareness alone is not enough. One must learn mitigation strategies for each of the biases.

To this end, please consider participating in our Mitigating Bias, Blindness and Illusions in E&P Decision Making course. This course is unique in that we offer specific mitigation techniques and strategies for each type of cognitive error reinforced with real-world, practical examples and exercises. Participants regularly comment that it is one of the best and most impactful industry courses that they have ever taken.

Training is only the beginning of the journey. One must continually be vigilant and ensure one engages in reflective thinking. If not, it is all too easy to fall back into old and familiar patterns of judgment and decision-making. Colleagues should work together to spot where a bias has affected an interpretation and seek rectification strategies.

Before I go, I would like to thank some of my colleagues that helped me publish these blogs. Gary Citron and Lisa Ward, whose editing of my blogs has made them read so much better; Doug Weaver and Lisa Ward for their support in this initiative of writing articles on bias; all my colleagues at Rose & Associates who provided inspiration and guidance for the many topics we have explored over the past year; and finally, to all readers who joined me on this journey.

I would also like to thank my BG work colleagues, Mark Simmons and Richard Wrigley. They joined the assurance team that I designed and managed, together giving guidance and support to technical teams and decision-makers. It was in this role where we first observed the poor predictions and decisions that led me on my path to understand how cognitive biases impact us, and the resultant R&A course (linked above) which Creties Jenkins and I created.

This has been a fun journey. Please do not hesitate to reach out to me anytime to discuss biases, examples that you have seen, or strategies you have invoked to mitigate. Be sure to look for the next series of blogs on the field of Assurance, coming soon to a screen near you!

Please visit our website to view other Rose & Associates blogs.

I wish you all the best.

Stay safe and healthy.

Marc Bond
Rose & Associates