- **Optimism Bias**: (Weinstein, 1980) (Lovallo D. &., 2003)
    - **Definition:** Tendency to underestimate time, costs, and risks while overestimating benefits.
    - **Impact:** Overly optimistic (inaccurate) forecasts lead to project cost and schedule overruns.
    - **Mitigation:**
        - Use reference class forecasting: Base estimates on actual performance from a reference class of comparable projects.
        - Be transparent and realistic in scheduling and cost estimation.
- **Anchoring Bias**: (Tversky, 1974)
    - **Definition**: Relying too heavily on initial information (the "anchor") when making estimates.
    - **Impact:** Initial estimates become fixed points, affecting subsequent adjustments even when new information or data suggests otherwise.
    - **Mitigation:**
        - Use reference class forecasting to avoid over-reliance on initial estimates.
        - Consider a range of possible outcomes.
- **Confirmation Bias**: (Nicherson, 1998)
    - **Definition:** Searching for, interpreting, and remembering information that confirms preexisting beliefs or expectations.
    - **Impact:** Can lead to ignoring evidence that contradicts initial estimates.
    - **Mitigation:**
        - Encourage a diverse team to challenge assumptions.
        - Seek out disconfirming evidence.
        - Use reference class forecasting including a full range of relevant historical data.
- **Availability Bias**: (Tversky, 1973)
    - **Definition**: Tendency to prioritize information or events that come to mind easily.
    - **Impact:** Can skew estimates based on recent experiences by overestimating the likelihood of events or the importance of information.
    - **Mitigation:**
        - Use historical data and reference class forecasting.
        - Avoid relying solely on personal anecdotes.
- **Hindsight Bias**:
    - **Definition**: Seeing events as having been predictable after they have occurred.
    - **Impact:** Leads to overconfidence in future estimates based on past successes.
    - **Mitigation:**
        - Document assumptions and reasoning during estimation.

        - Reflect on lessons learned from previous projects.

- **Expert Bias**:
    - **Definition**: Over-reliance on the judgment of experts (who themselves may have bias).
    - **Impact:** Experts consciously or subconsciously include bias leading to optimistic or pessimistic estimates. Can also affect risk assessment which is often calculated based on expert opinion. May cause one to disregard data or input from less experienced team members.
    - **Mitigation:**
        - Experts should be trained to recognize and mitigate bias.
        - Perform external review for reasonableness.
        - Use of parametric models which are objective and repeatable, being aware that bias in parameter inputs may lead to misestimation.

- **Groupthink**:
    - **Definition**: Desire for harmony or conformity in a group, leading to irrational decision-making.
    - **Impact:** Discourages creativity and individual responsibility. Can also suppress dissenting opinions and innovative ideas.
    - **Mitigation:**
        - Have a diverse composition of participants offering different perspectives.
        - Promote open discussion allowing all team members to voice their opinions and ideas.
        - Welcome skepticism and challenges to status quo to foster critical and independent thinking.

- **Survivorship Bias**:
    - **Definition**: Concentrating on successful projects while ignoring failures.
    - **Impact:** Creates a skewed view of success and failure leading to unrealistic expectations by not considering the full range of factors that contribute to outcomes.
    - **Mitigation:**
        - Actively seek out and consider data from both successful and unsuccessful projects.
        - Ensure all data sources are considered to include the full distribution of outcomes.

- **Recency Bias**:
    - **Definition**: Giving undue weight to recent events compared to earlier ones.
    - **Impact:** Distorts perceptions and decisions and therefore skews estimates by not considering all available data sources, irrespective of recency, especially if recent experiences are not representative.

    - **Mitigation:**
        - Use all available historical data and reference class forecasting.
        - Avoid relying solely on the most recent events.

- **Commitment Bias (Escalation of Commitment)**
    - **Definition**: When we persist in following through with an unsuccessful idea or action, rather than admitting that it was a mistake. This is especially true when we have made public commitments.
    - **Impact:** Hinders objective decision-making by focusing on past commitments, leading one to make decisions that are not in their best interest. Often causes people to persist in failing endeavors. They refuse to accept that the resources already invested cannot be recovered and instead, insist on more spending to justify the initial investment.
    - **Mitigation:**
        - Regularly assess progress against baseline estimate using objective measures and make necessary adjustments.
        - Limit personal attachment to reduce emotional investment. Make data-driven decisions based upon observed progress (or lack thereof).
- **Framing Effect**:
    - **Definition**: The way information is presented affects decisions and judgments. It is a cognitive bias where people decide on options based on whether the options are presented with positive or negative connotations.
    - **Impact:** Leads to biased decision making that can result in overly optimistic or pessimistic project estimates.
    - **Mitigation:**
        - Take an “outside view” and try to reframe the problem to examine different outcomes.
        - Have a standardized process for project estimation.

The following provides further insight into some of the aforementioned biases.

The concept of **optimism bias** was first named by psychologist Neil Weinstein in 1980, who used the phrase “unrealistic optimism” to describe this cognitive bias. Winston Churchill once said, "A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty." Research shows that, on average, human beings are hardwired to be optimists. This bias leads individuals to believe they are less likely to experience negative events, even when evidence suggests otherwise. In other words, optimism bias refers to our tendency to overestimate positive outcomes and underestimate negative ones. Optimism bias might cause people to underestimate the budget and time needed for a project, leading to the planning fallacy, discussed later. One should look to temper optimism with realism (i.e., data).

Anchoring bias was first identified by psychologists **Amos Tversky** and **Daniel Kahneman** in the 1970s. They proposed that anchoring bias occurs because the initial anchor—whether external (provided by others) or internal (based on beliefs or experiences)—serves as a reference point for subsequent judgments. This cognitive bias can lead people to rely too heavily on the first piece of information they receive, even if it's inaccurate, affecting decisions in various contexts. Even when presented with additional information, people tend to give too much weight to the original anchor, leading to distortions in judgment and decision-making. Inaccurate adjustments from an anchor value can render erroneous final decisions and estimates.

The **availability bias**, also known as **availability heuristic**, was also identified by psychologists **Amos Tversky** and **Daniel Kahneman** in 1973. A heuristic is a mental shortcut or rule of thumb used to make decisions. Individuals judge the likelihood of an event based on how easily examples or instances come to mind. Essentially, we judge the likelihood of an event based on how easily we can recall similar events.

In general, mental shortcuts are helpful because they allow us to reach a conclusion or make a choice quickly. If we had to factor in every piece of information when making everyday choices, we would spend too much time trying to find the best possible answer.

While heuristics are helpful, they can also lead to biased decision-making and sub-optimal choices.

Confirmation bias is a cognitive tendency where individuals seek or interpret information that aligns with their existing beliefs. English psychologist Peter Wason coined the term, highlighting how people favor data that confirms their views even if it means ignoring opposing viewpoints. This often stems from the need for self-esteem.

Recency bias, also known as **availability bias**, is a cognitive error identified originally in behavioral economics. It leads people to incorrectly believe that recent events will occur again soon. Essentially, it causes individuals to overweigh new information or events without considering their objective probabilities over the long run. Overweighting recent (i.e., available) information is irrational since it does not accurately reflect the true probabilities of future events

Logical Fallacies and Their Impact on Project Estimation

In addition to cognitive bias, fallacies also contribute to flawed thinking that leads to negative impacts on project estimating. While biases and fallacies seem similar, they are not the same. A fallacy is a pattern of reasoning that contains a flaw, either in its logical structure or in its premises whereas cognitive biases are systematic errors in thinking that affect the decisions and judgments that people make. Both cognitive biases and logical fallacies can lead to significant errors in project estimation, although in different ways. Being aware of both biases and fallacies can help inform decision makers and the estimating team, resulting in credible and defensible estimates.

Some logical fallacies that often impact project estimation include:

1. **Fallacy of Silent Evidence**: (Taleb, 2007)

    - **Definition**: Focusing only on visible successes while ignoring failures.
    - The concept of silent evidence was highlighted by **Nassim Taleb**. It refers to the overlooked bulk of information that often remains unconsidered in arguments or decision-making processes.
    - **Impact**: Leads to overly optimistic estimates.
    - **Mitigation**: Analyze a comprehensive dataset including failures and conduct failure reviews.

2. **Error of Causal Analysis**:
    - **Definition**: Incorrectly inferring causation from correlation.
    - **Impact**: Leads to flawed estimates and strategies.
    - **Mitigation**: Distinguish between correlation and causation, use experimental methods, and consult experts.

3. **Texas Sharpshooter Fallacy**:

    - **Definition**: Cherry-picking data clusters to suit an argument.
    - This fallacy was identified by **Nassim Taleb**. It occurs when differences in data are ignored, but similarities are overemphasized, leading to false conclusions. Imagine a Texan firing a gun at the side of a barn, then painting a target around the tightest cluster of shots and claiming to be a sharpshooter
    - **Impact**: Leads to misleading conclusions and inaccurate estimates.
    - **Mitigation**: Use all available data and apply rigorous statistical methods.

4. **Narrative Fallacy:**

    - **Definition:** Creating coherent and plausible stories out of random or incomplete data, leading to oversimplified explanations and overlooked complexities.
    - The concept of narrative fallacy was also introduced by **Nassim Taleb**. It refers to our tendency to connect unrelated facts into a coherent story, even when there's no actual evidence linking them. Our minds naturally seek patterns and create narratives, but this can lead to inaccuracies and oversimplifications.
    - **Impact**: Leads to oversimplified explanations, unrealistic projections, and overlooked complexities.
    - **Mitigation**:
        - **Data-Driven Analysis:** Rely upon data analysis rather than anecdotal evidence or compelling stories. Use statistical methods to identify trends and correlations.

        - Distinguish between the story (narrative) and the data analysis. Base decisions upon data (evidence) and not the story.
    - Develop best-case, worst-case, and most likely outcomes and prepare for uncertainties.
    - Involve diverse stakeholders to challenge the narrative and provide alternative viewpoints.

5. **Planning Fallacy:**

    - **Definition:** The planning fallacy occurs when predictions about task completion time display an optimism bias. People underestimate how long a future task will take, even if they know similar tasks have taken longer in the past.
    - The planning fallacy, which occurs when predictions underestimate the time needed for a task, was first proposed by psychologists **Daniel Kahneman** and **Amos Tversky** in 1979. It reflects our natural optimism and affects both individual and group tasks. Interestingly, while we recognize past over-optimism, we often insist our current predictions are realistic.
    - **Mitigation**: Use reference class forecasting. Before estimating project completion time, compare it to similar past projects, grounding predictions in historical data.

While neither a cognitive bias nor a logical fallacy, there is a behavioral bias worth noting given the frequency of occurrence and its negative impact on project estimation known as Strategic Misrepresentation.

- **Strategic Misrepresentation**:
    - **Definition**:
        - Deliberate underestimation of costs and overestimation of benefits to get a project approved.
        - Differs from Optimism Bias due to the deliberative nature, often to further one's own interests.
    - **Impact**: Leads to cost overruns, a shortfall of benefit realization and often inefficient resource allocation.
    - **Mitigation**:
        - Use reference class forecasting
        - Foster a culture where honesty and transparency are valued and rewarded. (As project estimators, we need to be recognized as the "truth tellers.")

Real-World Examples in Aerospace and Defense

1. **F-35 Joint Strike Fighter Program**: (United States Government Accountability Office (GAO), 2021)

- **Biases Involved**: Optimism Bias, Planning Fallacy, Groupthink
- **Impact**: Initial cost estimates were about $233 billion, but the total cost is now expected to exceed $1.7 trillion due to significant cost overruns and delays.
- **Lessons**: Overly optimistic projections and underestimation of technical challenges led to issues. Better planning, conservative risk assessments, and diversified stakeholder input could have helped.

2. **Mars Climate Orbiter**: (NASA, 1999)

   - **Biases Involved**: Planning Fallacy, Anchoring Bias
   - **Impact**: The orbiter was lost in 1999 due to a failure to convert units from English to metric, leading to a trajectory error.
   - **Lessons**: Over-reliance on initial data (anchoring) and underestimating the complexity of unit conversion (planning fallacy) caused the failure. Thorough checks and standardized procedures could have mitigated this.

3. **Comanche Helicopter Program**:

   - **Biases Involved**: Optimism Bias, Strategic Misrepresentation
   - **Impact**: The program was cancelled after spending nearly $7 billion, as it became clear that the initial estimates were vastly underestimated.
   - **Lessons**: Over-optimistic projections and strategic misrepresentation to secure funding led to wasted resources. More realistic estimates and assessments along with transparent reporting could have resulted in a better outcome.

4. **F-22 Raptor**:

   - **Biases Involved**: Optimism Bias, Commitment Bias
   - **Impact**: The project faced cost overruns and delays, with total program costs exceeding $66 billion for 195 aircraft (8 test and 187 production aircraft). The USAF originally envisioned ordering 750 aircraft at a total program cost of $44.3 billion.
   - **Lessons**: Overestimation of capabilities and continued investment despite issues (escalation of commitment) led to problems. Periodic reevaluation (estimations) and willingness to adjust plans could have helped.

6. **Concorde Supersonic Airliner**:
   - **Fallacy Involved:** Narrative Fallacy
   - **Context**: The project aimed to create a commercially viable supersonic passenger airliner.
   - **Narrative**: The developers believed that technological superiority and national pride would guarantee commercial success.

- **Impact**: Despite technical success, the project was economically unfeasible due to high operational costs and limited market demand. The coherent narrative of technological triumph overshadowed the economic realities.
- **Lessons**: Emphasizing comprehensive market analysis, performing comprehensive lifecycle estimates, and realistic economic assessments over compelling narratives could have prevented this failure.

7. **Airbus A380**:
    - **Fallacy Involved:** Narrative Fallacy
    - **Context**: The development of the world's largest passenger airliner.
    - **Narrative**: The narrative of unprecedented passenger capacity and luxury led to high expectations for market domination.
    - **Impact**: Despite initial excitement, production delays, cost overruns, and shifting market preferences toward smaller, more efficient aircraft reduced the program's viability.
    - **Lessons**: Producing credible estimates, factoring in industry trends, and potential shifts in market preferences could have provided a more accurate project outlook than an appealing narrative.

Mitigation Strategies

To mitigate biases, several previously mentioned strategies can be applied:

1. **Reference Class Forecasting (RCF)**: (Flyvbjerg B. , 2006)

    - **Definition**: Using statistical data from similar projects to predict the outcomes of the current project.
    - **Application**: Identify a reference class of similar past projects, gather data on actual performance, use this data to create a baseline estimate, and adjust for differences.
    - **Benefits**: Reduces optimism and anchoring biases by relying on empirical data. It allows us to learn from the past and make better predictions.

      Note: In the absence of collected/available data, commercial parametric models are based in part on a reference class of past projects. The use of commercial parametric models can enhance the process of reference class forecasting by providing a structured, comprehensive, and systematic approach to analyzing historical data and predicting future outcomes. These models can help in identifying relevant reference classes and in developing credible and reliable estimates. These models also guide an estimator to the questions they should be asking/answering by eliciting inputs to the appropriate cost driving parameters.

2. **Using Historical Data**:

    - **Definition**: Leveraging data from previous projects to inform current estimates.
    - **Application**: Maintain a repository of past project data, analyze trends, use statistical analysis to uncover patterns, and apply these insights to inform estimates.

      Again, if a proper or sufficient data collection has not been performed, consider using commercial parametric models that have done data collection and normalization, and/or databases such as ISBSG for software projects.
    - **Benefits**: Provides a reality check and helps calibrate expectations.

3. **Involving Diverse Perspectives**:

    - **Definition**: Including input from a wide range of stakeholders and team members.
    - **Application**: Organize cross-functional workshops, encourage open discussion, use techniques like the Delphi method, and ensure representation from both experienced and less experienced team members.
    - **Benefits**: Reduces groupthink and confirmation bias, leveraging collective wisdom.

4. **Applying Structured Decision-Making Processes**:

    - **Definition**: Implementing formal methodologies and frameworks to guide the estimation process.
    - **Application**: Use Uncertainty Analysis or Monte Carlo simulation to account for uncertainty and variability in estimates. Use decision trees, standardized templates, and checklists to evaluate different scenarios and their probabilities.
    - **Benefits**: Provides a systematic approach to estimation, reduces reliance on intuition, and enhances transparency.

5. **Data-Driven Analysis**:

    - **Definition**: Relying on comprehensive data analysis rather than anecdotal evidence or compelling stories.
    - **Application**: Use statistical methods to identify trends and correlations.
    - **Benefits**: Mitigates narrative fallacy by grounding decisions in data.

6. **Scenario Planning**: (Shoemaker, 1995)

    - **Definition**: Developing multiple scenarios, including best-case, worst-case, and most likely outcomes.

- **Application**: Understand the full range of possibilities and prepare for uncertainties.
- **Benefits**: Reduces the impact of narrative fallacy by considering diverse outcomes.

7. **Critical Review**:

   - **Definition**: Encouraging critical review and skepticism.
   - **Application**: Involve diverse stakeholders to challenge the narrative and provide alternative viewpoints.
   - **Benefits**: Reduces groupthink and confirmation bias.

8. **Incremental Validation**:

   - **Definition**: Validating assumptions and projections incrementally through pilot projects or phased implementations.
   - **Application**: Allow for course corrections based on real-world feedback.
   - **Benefits**: Identifies and addresses issues early, mitigating the impact of planning fallacy.

9. **Value and Demand Analysis**:

   - **Definition**: Hypernomics finds that all markets work with four or more opposing mathematical (as opposed to physical) dimensions as it reveals the ways markets form. (Some of you may already be familiar with Hypernomics and Doug Howarth who is active in ICEAA).
   - **Application**: For early identification of market thresholds, limits, and responses to product features offered to the buyers that make up the given market. Also to identify open spaces in existing markets where optimizing new product features provides the market with what it wants, doesn't have, and can afford.
   - **Benefits**: Identifies market positions to determine product viability and the extent that buyers will support it. Helps balance Cost, Value, and Demand before significant investments and resources are expended.
     - This would have certainly been beneficial for the Concorde Supersonic Airliner, A380, Comanche, and perhaps others mentioned previously.

Incorporating Lessons from Daniel Kahneman (Kahneman D. , 2011)

"Thinking, Fast and Slow" by Daniel Kahneman explores how our minds operate through two distinct systems:

System 1: This automatic, intuitive system operates quickly and effortlessly. It is responsible for snap judgments, instincts, and impulsive reactions. Think of it as the brain's autopilot. For example, when you swerve to avoid an obstacle while driving, System 1 is at play.

System 2: This deliberate, analytical system requires effort and conscious thought. It is engaged when you perform calculations, solve complex problems, or focus on details to make informed decisions. For instance, when you carefully compare different design alternatives or evaluate different manufacturing options, System 2 is active.

Kahneman explains how these systems shape our judgments, decisions, and actions, leading to both errors and insights. The book provides valuable insights for better decision-making and understanding our cognitive biases, some of which have been described previously.

The key is knowing when to engage System 1 and when to switch to System 2. One would typically use System 1 for routine decisions while applying System 2 for critical decisions that require detailed analysis, such as risk assessments.

For example, System 1 may lead to biases. The availability bias previously described, where decisions are influenced by what comes to mind most easily might lead one to overestimate the likelihood of a recently experienced problem recurring, even if the context is different. One needs to be cognizant when making decisions, particularly if they are employing System 1 when System 2 is more appropriate to pause and be more deliberate in decision making.

The theories behind reference class forecasting were developed by Daniel Kahneman and Amos Tversky. The theoretical work helped Kahneman win the Nobel Prize in Economics.

In their article “Delusions of Success: How Optimism Undermines Executives’ Decisions,” Dan Lovallo and Daniel Kahneman explored how executives often fall prey to the planning fallacy.

The planning fallacy can have serious consequences, both personally and professionally. In a professional setting, missed deadlines and unmet goals can lead to a loss of credibility, trust, and financial consequences. In a personal setting, the planning fallacy can lead to disappointment and frustration when individuals are unable to complete tasks or meet their own expectations.

As defined previously, reference class forecasting is so named as it predicts the outcome of a planned action based on actual outcomes in a reference class of similar actions to that being forecasted/estimated. Kahneman asserted that people tend to underestimate the costs, completion times, and risks of planned actions, whereas they tend to overestimate the benefits of those same actions (Optimism Bias). This is caused by people taking what he refers to as an **"inside view."**

Kahneman and Tversky concluded that the major source of error in forecasting can be attributed to disregarding distributional information. Therefore, they recommended that forecasters "should therefore make every effort to frame the forecasting problem so as to facilitate utilizing all the distributional information that is available." Using distributional information from previous ventures like the one being forecast is called taking an **"outside view"** since it does not rely on specific estimates of the project manager (inside view); rather it

compares the project to a statistical distribution of similar historical projects, resulting in more credible estimates.

He describes other ways to achieve an **"outside view."** Taking an outside view may involve getting input from independent sources that do not have a vested interest in the project's success. Alternatively, invite your "inner outsider" to the table. In other words, imagine that a friend has asked for help in preparing for the same estimate. What advice would you give them? The answer is your **outside** perspective.

Incorporating Lessons from Bent Flyvbjerg (Flyvbjerg B. , 2014) (Flyvbjerg B. a., 2023)

Bent Flyvbjerg, a prominent scholar in project management and planning, has extensively studied why large projects fail and how to mitigate these failures. His work highlights the role of cognitive biases, strategic misrepresentation, and poor decision-making processes. Incorporating his lessons can significantly improve the accuracy and reliability of project estimates.

Flyvbjerg promotes reference class forecasting and warns against strategic misrepresentation, both of which have been written about earlier. Some other lessons and mitigation strategies from him include:

- **Independent Reviews**: Use independent reviewers to assess project estimates and identify potential biases or misrepresentations.
- **Transparency and Accountability**: Ensure transparency in the estimation process and hold stakeholders accountable for their estimates while also ensuring that they are based on data and evidence.
- **Modular Approach**: Break large projects into smaller, more manageable modules that can be independently estimated and monitored.
- **Phased Implementation**: Implement projects in phases, using feedback from earlier phases to inform estimates and plans for subsequent phases.
- **Contingency Planning**: Include contingency plans and buffers to account for unforeseen issues and risks.
- **Monitoring and Reporting**: Establish robust monitoring and reporting mechanisms to track project progress and identify deviations from plans.
- **Risk Management**: Develop comprehensive risk management strategies that include regular risk assessments and mitigation plans.

Conclusion

Project estimating is susceptible to various cognitive biases and logical fallacies that can lead to significant inaccuracies often leading to cost overruns, delays, and project failures. By

understanding these biases and applying mitigation strategies such as reference class forecasting, using historical data, involving diverse perspectives, and implementing structured decision-making processes, project managers can improve the accuracy and reliability of their estimates.

Finally, underpinning many of the mitigation strategies is the use of data, which leads me to two quotes from Dr. W. Edwards Deming: (Deming, 1986)

"In God we trust. All others must bring data."

and

"Without data you're just another person with an opinion."

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