

Engineering Ethics: The Avoidance of Confirmation Bias in Professional Practice

Continuing Education for Professional Engineers

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Course Description

This course explores the intersection of engineering ethics and cognitive bias, with a focus on confirmation bias and its influence on engineering judgment, decision-making, and professional responsibility.

Engineers are ethically obligated to safeguard public health, safety, and welfare by making objective, evidence-based decisions. However, confirmation bias can subtly distort the design process, risk evaluation, reporting, and peer review. Through case studies, ethical frameworks, and practical methodologies, this course equips engineers with strategies to recognize and counteract bias, ensuring integrity in professional practice.

Course Objectives

Upon completion of this course, participants will be able to:

- Understand the principles of engineering ethics as defined by major professional societies and licensing boards.
- Define confirmation bias and explain how it manifests in engineering decision-making.
- Recognize ethical risks associated with biased judgment, including misrepresentation of data and compromise of public safety.
- Apply structured ethical reasoning and decision frameworks to counteract confirmation bias.
- Evaluate real-world case studies where confirmation bias influenced engineering outcomes.
- Develop practical strategies for promoting objectivity in analysis, reporting, and peer review.

Intended Audience

This course is intended for engineers across disciplines such as civil, mechanical, electrical, and systems engineering who are responsible for design, analysis, reporting, and peer review. It is particularly suited for professionals seeking to strengthen ethical decision-making, and reduce bias in technical judgments where objectivity and ethical integrity are critical.



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Chapter 1: Foundations of Engineering Ethics



The Role of Ethics in Engineering Practice

Engineering ethics is the framework of principles and values that guide professional engineers in their conduct, decision-making, and responsibility to society. It provides the foundation upon which engineers uphold integrity in practice, safeguard public welfare, and maintain trust in the profession.

Ethics is not simply an abstract philosophy in engineering, it is a practical necessity. The consequences of engineering decisions often involve public safety, environmental impacts, financial investments, and long-term societal outcomes. For this reason, engineers are held to a higher standard of accountability than many other professions.

Core Pillars of Engineering Ethics

At its core, engineering ethics emphasizes three pillars: honesty, responsibility, and public protection. Engineers must not misrepresent facts, conceal risks, or pursue personal or client interests at the expense of public safety. The responsibility extends beyond compliance with technical codes and legal requirements; it requires engineers to use professional judgment guided by fairness, prudence, and objectivity.



Professional Codes and Standards

Professional societies such as the National Society of Professional Engineers (NSPE), the American Society of Civil Engineers (ASCE), and other discipline-specific organizations have codified ethical standards that serve as guiding documents. While these codes vary in language, they consistently emphasize the primacy of public safety, the obligation to present truthful and complete information, and the responsibility to avoid conflicts of interest.

For licensed engineers, these principles are not optional guidelines; they are enforceable duties under state licensing boards, which may revoke licensure or impose penalties for ethical violations.

Competence and Continuing Education

The foundations of engineering ethics also include the obligation to maintain professional competence. Engineers must remain current with evolving technology, standards, and methodologies, as outdated or uninformed decisions can compromise safety and violate ethical duties. In this way, ethics and continuing education are inseparable, since lifelong learning is necessary to ensure responsible practice.

Ethics is a Preventative Framework

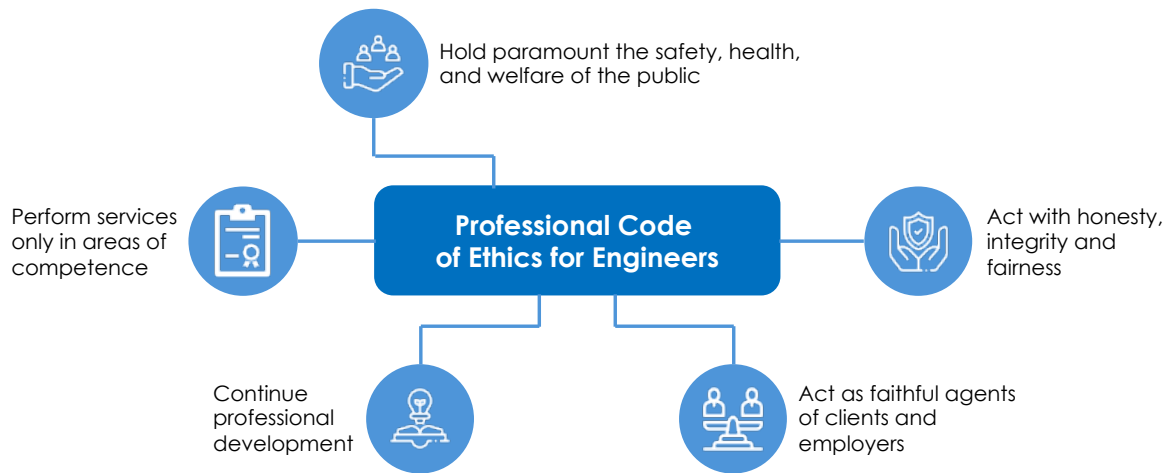
Finally, ethics in engineering is inherently preventative. Engineers must make choices that anticipate risks rather than simply react to them. This forward-looking mindset requires the ability to identify blind spots, avoid cognitive shortcuts, and resist biases that cloud judgment. While technical tools help quantify risk, ethics helps engineers weigh the human consequences of their actions and remain vigilant against self-deception.

Summary

The foundation of engineering ethics is not just compliance with codes but the cultivation of a professional mindset: one that prioritizes truth, embraces responsibility, and acknowledges that engineering decisions carry ethical weight as well as technical complexity.



Chapter 2: The Engineer's Duty to Protect Public Health, Safety, and Welfare



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Primacy of Public Welfare in Ethical Codes

The foremost ethical responsibility of every professional engineer is the protection of public health, safety, and welfare. This principle is emphasized in every engineering code of ethics and serves as the cornerstone of professional accountability. Unlike purely commercial or academic endeavors, engineering practice directly influences the environments where people live, work, and travel. The duty to protect the public elevates engineering from a technical occupation to a profession grounded in societal trust.

The National Society of Professional Engineers (NSPE) Code of Ethics articulates this duty by declaring that engineers “shall hold paramount the safety, health, and welfare of the public.” Similar mandates are reflected in the ethical codes of civil, electrical, mechanical, and chemical engineering societies worldwide. State licensing boards adopt and enforce these provisions, making the duty to protect the public not only an ethical obligation but also a legal requirement of professional licensure.

This responsibility requires engineers to evaluate risks comprehensively and objectively. Designs must not only meet minimum regulatory standards but also provide safety margins that anticipate potential failures, misuse, and unforeseen conditions. For example, structural engineers account for seismic loads even in areas where earthquakes are rare, while environmental engineers design containment systems that protect communities from accidental spills. Such



foresight reflects the ethical principle that human welfare must never be compromised for expediency or cost savings.

Transparency and Communication of Risks

The duty also extends to the communication of risks. Engineers must present findings and recommendations honestly, even when the information is unwelcome to clients, employers, or government agencies. Concealing hazards or downplaying risks constitutes a violation of ethical standards. Transparency ensures that decision-makers, stakeholders, and the public are aware of the potential consequences and can take informed action.

Conflicts of Interest and Ethical Pressures

Conflicts of interest can endanger this duty. Engineers may face pressure from clients to reduce costs, accelerate timelines, or overlook inconvenient findings. Ethical responsibility requires resisting such pressures and placing the welfare of the public above financial or political interests. An engineer who yields to these pressures compromises not only their professional integrity but also the safety of those who depend on their expertise.

Environmental Stewardship and Sustainability

In addition, the duty to protect public welfare encompasses environmental stewardship. Engineering projects often interact with ecosystems, water supplies, and air quality. Ethical responsibility requires engineers to design with sustainability in mind, ensuring that immediate benefits do not create long-term harm. The welfare of future generations must also be considered when evaluating engineering decisions.

Summary

Ultimately, the ethical obligation to safeguard health, safety, and welfare is what distinguishes engineering from technical labor. It is a professional duty that transcends individual interests and demands impartial, evidence-based decision-making. This principle sets the stage for the deeper challenge: understanding how human biases, such as confirmation bias, can compromise an engineer's ability to fulfill this duty responsibly.



Chapter 3: Introduction to Cognitive Bias in Human Decision-Making

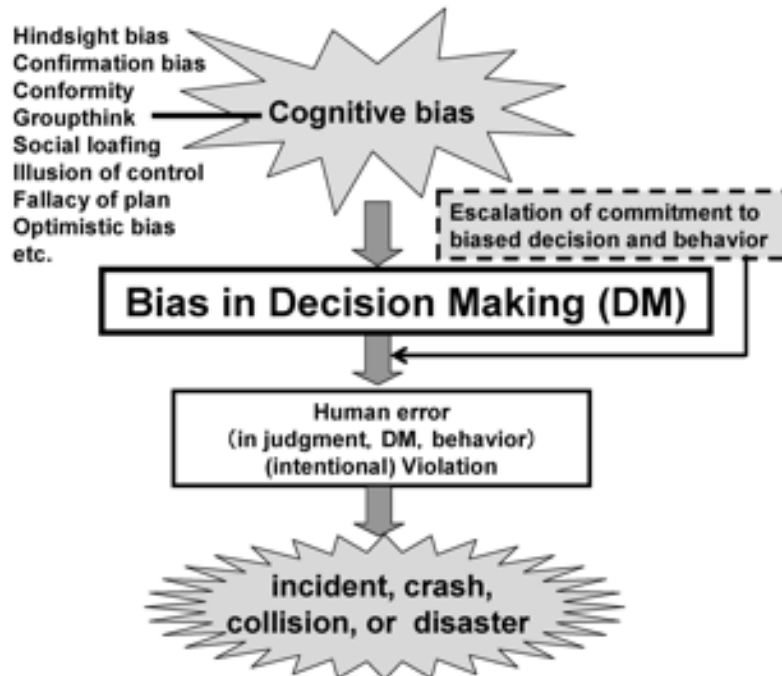


Figure 1: Relational model between cognitive biases and decision making

Credit: Murata et al., 2015

Heuristics and Cognitive Shortcuts

Engineers, like all people, rely on mental shortcuts to process large amounts of information and make decisions under time and resource constraints. While these shortcuts, known as heuristics, are often efficient, they can also produce systematic errors in judgment. These errors are called cognitive biases (Figure 1).

Cognitive biases are not intentional acts of deception or negligence; rather, they arise from the natural ways human cognition simplifies complexity. However, in engineering, where objective accuracy is critical, these biases can distort decisions in ways that lead to ethical lapses and technical failures.

Definition and Impact of Cognitive Bias

Cognitive bias is the tendency to interpret information in a way that conforms to pre-existing beliefs, expectations, or desires. This psychological tendency helps the human mind reduce uncertainty, but it also introduces distortions. For engineers, the impact is significant: when assessing designs, testing data, or



failure reports, the presence of bias can lead to flawed conclusions even in the presence of valid technical evidence.

Confirmation Bias in Engineering Decisions

One of the most common biases in engineering decision-making is **confirmation bias**, the preference for information that supports an existing hypothesis while disregarding or undervaluing contradictory evidence. For example, an engineer who strongly believes a design is safe may unconsciously interpret test results in a favorable light, overlooking indications of risk. This creates a dangerous disconnect between perceived and actual performance.

Other forms of **cognitive bias** are also relevant. **Anchoring bias** occurs when too much weight is given to the first piece of information received, potentially skewing design assumptions. **Overconfidence bias** can lead engineers to underestimate uncertainties or dismiss alternative analyses.

Groupthink, a collective form of bias, emerges when teams suppress dissenting views to maintain harmony, often ignoring critical warnings that could prevent failure.

Consequence of Cognitive Bias in Practice

The consequences of bias are not abstract. History contains numerous engineering failures where cognitive distortions played a role. In some cases, teams ignored warning signs because they conflicted with the prevailing narrative of project success. In others, engineers trusted preliminary analyses too strongly, dismissing later findings that pointed to danger. Each of these instances represents not just a technical oversight but also an ethical failure to uphold the obligation of objectivity and public protection.

Understanding cognitive bias is the first step toward controlling its influence. By recognizing that these biases are universal, engineers can adopt structured practices, such as **independent peer review**, **systematic data analysis**, and **decision frameworks**, that minimize their effects. Ethics reinforces this process, as the commitment to honesty, transparency, and responsibility demands that professionals remain vigilant against self-deception.

Summary

This chapter establishes the connection between human psychology and engineering practice. In the next chapter, the focus will turn specifically to



confirmation bias, its mechanisms, and the particular dangers it poses within engineering design and analysis.



Chapter 4: Understanding Confirmation Bias and Its Psychological Basis

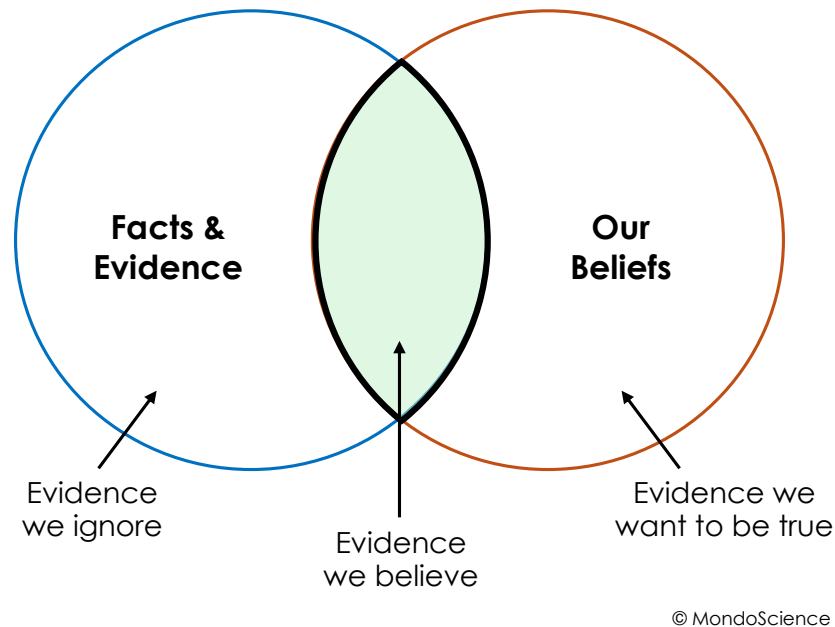


Figure 2: Confirmation bias

Defining Confirmation Bias

Confirmation bias is one of the most studied and persistent forms of cognitive bias. It occurs when individuals seek, interpret, or remember information in a way that affirms their existing beliefs or expectations while disregarding or minimizing contradictory evidence (Figure 2).

For engineers, who must make decisions based on objective data and sound analysis, confirmation bias presents a serious challenge because it can distort every stage of the design and evaluation process.

The psychological roots of confirmation bias lie in the way the human brain processes information. People are naturally inclined to seek coherence and reduce uncertainty. Once a belief or hypothesis is formed, the mind instinctively prefers information that reinforces it, since disconfirming evidence creates cognitive dissonance, or mental discomfort. This tendency is not intentional dishonesty but rather an unconscious mechanism to maintain consistency in thought.



Confirmation Bias in Engineering Practice

In engineering practice, confirmation bias often arises when an engineer or design team becomes overly invested in a particular concept or solution. After weeks or months of effort, they may view their design as “the correct one” and begin interpreting test results in a way that favors its success. For example, a structural engineer who strongly believes a bridge design is safe may give greater weight to test results that confirm this view while rationalizing away anomalies that suggest weaknesses.

The danger of confirmation bias is that it operates subtly. Engineers may believe they are acting objectively while their judgment is already compromised. They may unintentionally frame test parameters to produce the expected result, selectively highlight favorable data in reports, or dismiss conflicting opinions during peer review discussions. Each of these actions weakens the integrity of the engineering process and introduces ethical concerns, as the duty to present complete and accurate information is compromised.

Organizational and Systemic Bias

Confirmation bias can also manifest in organizational settings. Teams under pressure to meet deadlines or satisfy clients may collectively focus on evidence that supports project success, while ignoring signs of risk. In such cases, bias becomes systemic, embedded in the culture of the project. This heightens the ethical stakes, since ignoring contrary evidence not only misguides decision-makers but also endangers public safety.

The Role of Self-Awareness and Humility

Recognizing confirmation bias requires humility and self-awareness. Engineers must understand that their expertise, while essential, does not make them immune to psychological tendencies. Acknowledging the possibility of bias is not a weakness; it is a professional strength that aligns with ethical obligations. By doing so, engineers prepare themselves to apply corrective methods, such as independent verification, structured decision-making, and diverse peer review.

Summary

Understanding the psychological basis of confirmation bias provides the groundwork for identifying its effects on engineering practice. The following chapter will explore how this bias specifically distorts design, analysis, and risk assessment, illustrating its impact through practical engineering contexts.



Chapter 5: How Confirmation Bias Distorts Engineering Design and Analysis

Engineering design is fundamentally an iterative process that involves problem definition, conceptual development, modeling, testing, and refinement. At each stage, engineers rely on data, calculations, and professional judgment to arrive at solutions that are safe, effective, and efficient. When confirmation bias is introduced into this process, the very objectivity that underpins engineering practice is threatened. What follows are the ways in which confirmation bias can distort the design and analysis cycle.

Problem Definition

The earliest stages of design require engineers to correctly identify and define the problem to be solved. If confirmation bias is present, engineers may frame the problem in a way that favors a preconceived solution rather than allowing the requirements to emerge objectively.

For instance, a team that prefers a certain construction material may unconsciously define the problem in terms that highlight the material's strengths while minimizing its limitations. This can lead to a misalignment between the actual needs of the project and the chosen design path.

Conceptual Design and Alternatives

Good engineering practice calls for the consideration of multiple design alternatives before settling on a preferred option. However, confirmation bias can cause engineers to focus on the first acceptable idea, treating it as the "correct" solution and dismissing other possibilities prematurely.

This tendency not only reduces innovation but also undermines the ethical obligation to provide clients and the public with the best possible design based on all available information.

Modeling and Assumptions

Engineering models are powerful tools, but they are only as good as the assumptions built into them. Confirmation bias can lead engineers to select assumptions that favor their expected outcome. For example, in structural analysis, choosing overly optimistic load factors or ignoring worst-case scenarios



may make a design appear safer than it actually is. Such selective modeling introduces ethical concerns, as it represents an incomplete and biased assessment of risk.

Testing and Data Interpretation

Testing is designed to validate assumptions and refine designs. Yet, under confirmation bias, engineers may unconsciously interpret data in a way that supports the success of their design while minimizing unfavorable results. Test failures may be rationalized as anomalies rather than signals of deeper flaws. This practice contradicts the ethical principle of honesty in reporting and can mislead decision-makers, regulators, and the public.

Risk Assessment and Safety Margins

One of the most dangerous effects of confirmation bias occurs in risk assessment. If engineers believe strongly that a design is safe, they may dismiss indicators of potential hazards. In doing so, they reduce safety margins and increase the likelihood of failure.

The Challenger Space Shuttle disaster is a widely cited example of how engineers and managers, influenced by bias and organizational pressures, dismissed warnings about O-ring performance in cold conditions, leading to catastrophic failure.

Peer Review and Collaboration

Even in review processes designed to safeguard objectivity, confirmation bias can prevail. Reviewers may unconsciously reinforce the dominant perspective of the design team, especially if they share the same assumptions or face organizational pressure to support the project. This diminishes the corrective role of peer review and undermines the ethical obligation to ensure full scrutiny of engineering decisions.

Summary

In each of the areas discussed, confirmation bias undermines the integrity of engineering work by eroding objectivity. More critically, it transforms a technical weakness into an ethical issue, since biased judgment can mislead stakeholders, obscure risks, and ultimately compromise public safety. The next chapter will examine the tension between ethical principles and cognitive shortcuts, demonstrating how bias creates direct conflicts with professional codes of conduct.



Chapter 6: Ethical Principles versus Cognitive Shortcuts

Engineering ethics rests on clear principles: honesty, integrity, accountability, fairness, and the protection of public safety and welfare. These principles serve as guideposts for professional conduct, ensuring that engineers act in the best interests of society even under pressure from clients, employers, or external circumstances. Cognitive shortcuts, however, often stand in tension with these ethical obligations. While shortcuts may streamline thinking, they also create opportunities for bias to override professional judgment.

Cognitive shortcuts, or heuristics, are mental tools the brain uses to process information efficiently. In daily life, they are often harmless and practical. An engineer might rely on rules of thumb for estimating loads or familiar patterns when diagnosing system issues. Yet, when these shortcuts are taken too far, they can erode the careful scrutiny required in ethical practice. The key ethical danger is that heuristics allow biases, especially confirmation bias, to become embedded in professional decisions without conscious recognition.

Conflict with Honesty and Objectivity

The principle of honesty demands that engineers present data and findings in a truthful, complete, and unbiased manner. Confirmation bias conflicts with this requirement because it leads professionals to unconsciously select or emphasize only the evidence that aligns with their expectations. The result is incomplete reporting that, while not deliberately false, is ethically compromised.

Conflict with Accountability

Engineering accountability means being responsible for the outcomes of professional decisions. When shortcuts are used to reinforce prior assumptions, accountability diminishes because decisions are no longer based on comprehensive analysis. This violates the ethical duty to ensure that all reasonable risks have been considered and that the public interest is protected.

Conflict with Fairness

Fairness in engineering involves giving due consideration to all alternatives, stakeholders, and consequences. Cognitive shortcuts often limit the range of solutions considered, favoring familiar or convenient options. This undermines



the fairness of the process by prematurely excluding viable alternatives, often to the detriment of clients or the public.

Conflict with the Duty to Protect Public Safety

Perhaps the most critical conflict arises with the principle of safeguarding health, safety, and welfare. Cognitive shortcuts provide psychological comfort but may blind engineers to hazards. Ignoring or downplaying risk data because it is inconvenient violates the very essence of professional duty. In such cases, bias transforms from a cognitive error into an ethical breach with potentially catastrophic consequences.

Conflict with Continuing Competence

Ethical codes also emphasize the obligation to maintain competence. Reliance on shortcuts can encourage stagnation, where engineers repeatedly fall back on what is familiar rather than seeking updated methods or challenging their assumptions. This undermines the duty of lifelong learning, which is critical for ethical engineering practice.

The relationship between ethics and cognitive shortcuts is thus adversarial. While shortcuts arise naturally from human cognition, they must be actively countered through professional discipline.

Summary

Ethical engineering requires slowing down the mental process enough to ensure objectivity, completeness, and fairness. In practice, this means deliberately questioning assumptions, welcoming disconfirming evidence, and resisting the allure of conclusions that come “too easily.”

The next chapter will illustrate these conflicts more concretely through a case study where confirmation bias directly influenced engineering judgment, leading to failure and raising serious ethical questions.



Chapter 7: Case Studies – Confirmation Bias in Structural Engineering Failures

Case studies offer powerful insight into the ways confirmation bias undermines both technical performance and ethical responsibility in engineering. Structural engineering provides many examples where bias clouded judgment, leading to catastrophic outcomes. These failures demonstrate how technical errors, when coupled with psychological shortcuts, can compromise the ethical duty to protect the public.

Case Study 1: The Hartford Civic Center Roof Collapse (1978)

Background:

One of the most cited cases of structural failure influenced by bias is the Hartford Civic Center Coliseum roof collapse in Connecticut. The roof, built using an innovative space-frame design, collapsed under snow load only a few years after its completion. Fortunately, the event occurred at night, preventing mass casualties.

Outcome:

Subsequent investigations revealed that engineers had observed early signs of deflection in the roof but dismissed these concerns as inconsequential. Confirmation bias played a role in the team's judgment: having invested heavily in the novel design, they interpreted deflection data as normal rather than as an early indicator of failure.

Lesson Learned:

The ethical issue arose when engineers failed to disclose the seriousness of these anomalies, prioritizing confidence in their design over full transparency.

Case Study 2: The Hyatt Regency Walkway Collapse (1981)

Background:

Another tragic example occurred in Kansas City, where suspended walkways in a hotel atrium collapsed, killing 114 people.

Outcome:

Investigations revealed that a last-minute design change to the hanger rod connections doubled the load on a critical connection point (see Figure 3). Reviewers failed to rigorously analyze the change, assuming it did not



compromise safety. Here, confirmation bias emerged as a trust in familiar procedures and assumptions.

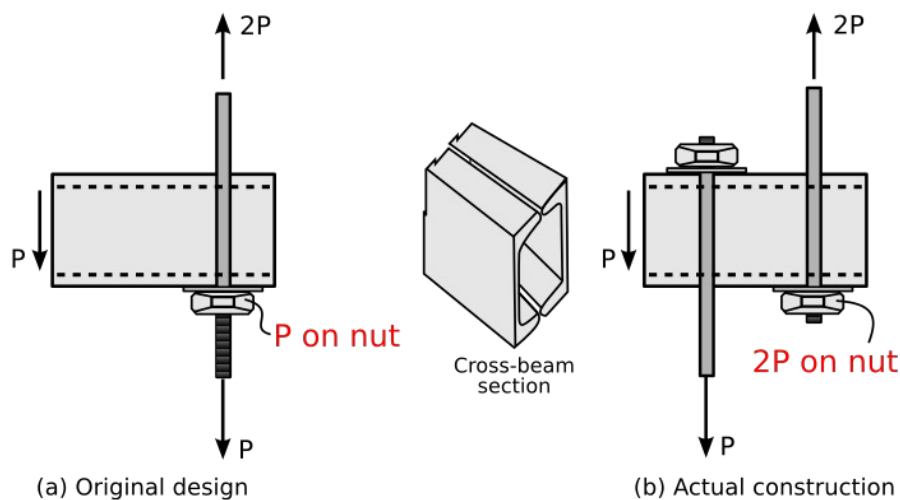


Figure 3: Cross beam design of the collapsed fourth-floor elevated walkway in the Hyatt Regency Hotel, USA. (a) Original connection design, (b) Modified design that led to the failure

Lesson Learned:

The reviewing engineers believed that because the original design had been sound, the modified version must also be safe. This failure of independent verification highlights the ethical consequences of allowing shortcuts and assumptions to override critical examination.

Case Study 3: The Challenger Space Shuttle Disaster (1986)

Background:

Although not a building failure, the Challenger disaster illustrates how confirmation bias influences engineering judgment.

Outcome:

Engineers at NASA and Morton Thiokol were aware of potential issues with O-ring seals in cold temperatures but rationalized the risk based on previous launches that had not resulted in failure. This selective interpretation of past data, a hallmark of confirmation bias, led to the fatal decision to proceed with launch.

*Lesson Learned:*

The ethical dimension was stark: the duty to prioritize public safety was compromised by pressures to stay on schedule and an organizational culture that dismissed contrary evidence.

Lessons from Structural Failures

These examples demonstrate several ethical lessons. First, engineers must be vigilant in recognizing that early warning signs are not inconveniences to be explained away but critical data requiring full attention. Second, peer review must be rigorous and independent, resisting the tendency to affirm prior conclusions without thorough re-examination. Third, engineers must uphold transparency, even when findings are unpopular or threaten project timelines.

Summary

Confirmation bias in structural failures is not merely a technical error but an ethical lapse, because the choice to interpret data selectively or overlook anomalies violates the principle of protecting public safety. The cases discussed here underscore why ethical responsibility demands conscious efforts to counteract bias at every stage of design and review.

The next chapter will examine confirmation bias in another important context: environmental and safety risk assessments, where the stakes are equally high but often less visible until failure occurs.



Chapter 8: Case Studies – Bias in Environmental and Safety Risk Assessments



Figure 4: Oil from the Deepwater Horizon oil spill approaching the coast of Mobile, Alabama, USA

Environmental and safety risk assessments are central to responsible engineering practice. They involve the systematic evaluation of potential hazards to human health, ecological systems, and infrastructure, followed by the development of mitigation strategies. Because such assessments often involve uncertainty and long-term projections, they are especially vulnerable to confirmation bias.

When engineers or organizations selectively emphasize evidence that supports their preferred outcomes, the ethical consequences can be severe, resulting in hidden hazards, long-term environmental damage, or threats to public health.

Case Study 1: The Love Canal Incident (1970s–1980s)

Background:

One of the most notorious examples of environmental misjudgment occurred at Love Canal in Niagara Falls, New York. A neighborhood was developed on land that had been used as a chemical waste dumping site.

*Outcome:*

For years, engineers and officials downplayed or ignored evidence of contamination despite growing reports of illness and birth defects in the community. Confirmation bias manifested as a tendency to trust prior assurances of safety while dismissing emerging data that suggested otherwise.

Lesson Learned:

The ethical breach was clear: instead of prioritizing public welfare, decision-makers favored interpretations that supported continued development and minimized liability.

Case Study 2: Deepwater Horizon Oil Spill (2010)

Background:

The Deepwater Horizon oil spill in the Gulf of Mexico was an environmental disaster (see Figure 4).

Outcome:

Investigations revealed that engineers and managers interpreted warning signs of well instability and equipment failure as minor anomalies rather than serious indicators of risk. Confirmation bias influenced decision-making by reinforcing the belief that the drilling project was proceeding safely, despite mounting evidence to the contrary.

Lesson Learned:

Ethical responsibility was compromised when the pressure to maintain schedules and reduce costs outweighed the duty to act on disconfirming evidence. The result was one of the worst environmental disasters in U.S. history, with massive ecological and economic consequences.

Case 3: Chernobyl Nuclear Accident (1986)

Background:

Though often attributed to flawed reactor design and procedural violations, the Chernobyl disaster also illustrates how bias affects risk assessment.

Outcome:

Plant operators and engineers dismissed data showing unstable conditions during an ill-conceived safety test. Their belief in the reactor's resilience overshadowed evidence of vulnerability. This selective interpretation of risk,



driven by overconfidence and confirmation bias, contributed to catastrophic failure.

Lesson Learned:

The ethical breakdown was not limited to technical design, it was also a failure to acknowledge and communicate the real risks to the public and operators.

Patterns in Risk Assessment Failures

Across these examples, certain patterns emerge. Engineers and organizations under pressure may view warning data as isolated anomalies rather than systemic indicators. They may resist acknowledging risks because doing so could delay projects, increase costs, or expose liability. In each case, confirmation bias interacts with external pressures, reinforcing the inclination to downplay negative evidence.

Ethical Lessons

The ethical implications of biased risk assessment are profound. Engineers have a duty to communicate risks fully and transparently, even when the evidence is uncertain or politically inconvenient. Ignoring or minimizing risk data violates this duty and places both current and future populations in harm's way. Ethical practice requires resisting the comfort of reassuring narratives and embracing the discomfort of confronting uncertainty.

Summary

These case studies highlight that environmental and safety risk assessments are not just technical exercises but ethical tests of professional integrity. Engineers must remain vigilant to ensure that their analyses are not shaped by bias but guided by the principle of protecting human and environmental welfare. The next chapter will examine how confirmation bias affects ethical reporting and the presentation of data, where subtle distortions in communication can have consequences as serious as errors in design or analysis.



Chapter 9: Ethical Implications of Biased Reporting and Data Presentation

Engineering ethics requires that all technical communication, whether reports, calculations, presentations, or testimony, be truthful, objective, and complete. When confirmation bias influences reporting, the accuracy of information is compromised. This not only undermines technical integrity but also violates the ethical principles of honesty and transparency that are foundational to professional practice.

Selective Use of Data

One way confirmation bias manifests in reporting is through selective inclusion of data. Engineers may present test results that align with their expectations while omitting or minimizing unfavorable findings. For example, in material testing, engineers might highlight strength results from optimal specimens while excluding data showing variability or weakness. While this may not constitute deliberate falsification, it distorts the true performance profile and denies stakeholders the full picture. Such omissions are ethically unacceptable because they can lead to uninformed or unsafe decisions.

Framing of Results

Even when all data are technically reported, bias can creep in through framing. Engineers may emphasize positive outcomes in executive summaries while relegating negative findings to appendices or technical notes unlikely to be scrutinized. This creates an impression of confidence that is not supported by the complete evidence.

Ethical responsibility requires engineers to ensure that critical risks or limitations are communicated with equal prominence to strengths and successes.

Visualization and Graphical Representation

The way data are graphed or visualized can also be influenced by bias. Choosing scales, colors, or statistical representations that make results appear more favorable than they are is a subtle but significant ethical violation. For example, compressing a vertical axis to minimize the appearance of structural deflection may mislead stakeholders about actual risks. Engineers must ensure that visual tools clarify truth rather than manipulate perception.



Overreliance on Supporting Evidence

Confirmation bias may lead to overemphasis of supporting studies or references while ignoring contradictory literature. When engineers cite sources selectively, they give decision-makers the false impression of unanimity in technical opinion. Ethical practice requires balanced representation of both supporting and conflicting evidence, particularly in areas where uncertainty or controversy exists.

Consequences of Biased Reporting

The ethical implications of biased reporting are profound. Decisions about public safety, environmental protection, and resource allocation often depend on the integrity of engineering reports. When these documents are shaped by confirmation bias, the consequences can range from financial loss to catastrophic failures with loss of life. Furthermore, biased reporting erodes trust in the engineering profession, as stakeholders and the public expect engineers to act as impartial stewards of truth.

The Ethical Standard

Professional codes of ethics leave no room for biased communication. Engineers must “issue public statements only in an objective and truthful manner” (NSPE Code of Ethics) and must not allow client, employer, or self-interest to compromise this obligation. Recognizing the potential for confirmation bias means adopting proactive measures, such as independent report reviews, transparent disclosure of limitations, and cautious interpretation of results, to ensure accuracy and fairness in communication.

Summary

The ethical implications of biased reporting extend far beyond technical missteps. They represent a breach of professional trust and a failure to uphold the highest duty of engineers: to protect the public through honest, objective, and complete communication.

The next chapter will explore how confirmation bias influences peer review and team collaboration, where collective thinking dynamics can magnify individual biases and create systemic ethical risks.



Chapter 10: Confirmation Bias in Peer Review and Team Collaboration

Peer review and collaborative teamwork are critical safeguards in engineering practice. They ensure that designs, calculations, and risk assessments receive scrutiny from multiple perspectives, reducing the likelihood of oversight. When these processes function properly, they act as a corrective mechanism against individual error. However, when confirmation bias infiltrates peer review and collaboration, the collective judgment of engineers can become distorted. Instead of challenging assumptions and exposing flaws, teams may reinforce biases and perpetuate errors, creating systemic vulnerabilities.

Peer Review under Bias

The purpose of peer review is to provide independent evaluation, but reviewers are not immune to psychological tendencies. Confirmation bias can cause reviewers to unconsciously agree with the prevailing assumptions of a project team, especially if they share the same background, training, or organizational pressures. In such cases, peer review becomes a formality rather than a safeguard. For instance, if the lead engineer expresses strong confidence in a design, reviewers may unconsciously search for evidence that supports the lead's position rather than probing for weaknesses.

Groupthink in Collaborative Settings

In team environments, confirmation bias often manifests as groupthink. This occurs when the desire for consensus overrides the responsibility to critically evaluate evidence. Dissenting opinions may be discouraged or suppressed, especially when project deadlines, budgets, or hierarchical authority create pressure to align with the majority. Groupthink not only reinforces existing biases but also creates an ethical hazard, as the team collectively neglects the duty to challenge unsafe or incomplete conclusions.

Case Example: Challenger Shuttle Decision-Making

The Challenger Space Shuttle disaster offers a clear example of bias in collaborative decision-making (Figure 5). Engineers raised concerns about the O-ring seals under cold weather conditions, but organizational pressures and managerial expectations led to their warnings being downplayed. The collaborative review process failed, not because engineers lacked knowledge,



but because bias and groupthink prevented dissenting evidence from being given proper weight. This demonstrates how systemic bias within teams can undermine ethical obligations to protect public safety.

Launch of space shuttle under severely cold condition and high risk of explosion

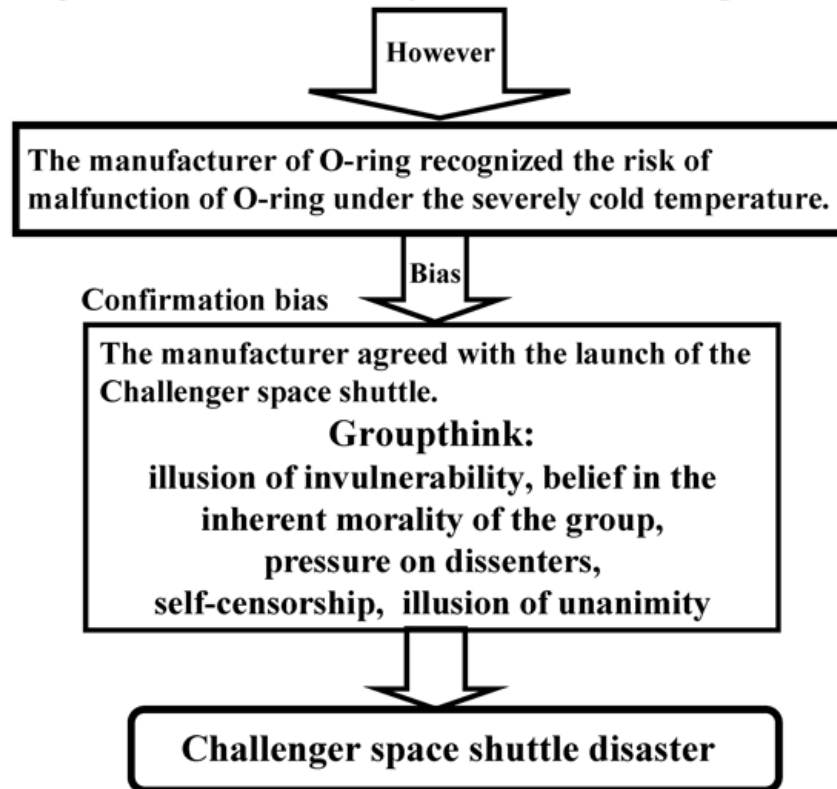


Figure 5: Decision-making in the Challenger Space Shuttle disaster

Credit: Murata et al., 2015

The Ethical Dimension

Ethically, engineers engaged in peer review or teamwork must act independently, even when independence is uncomfortable. The obligation to safeguard public welfare demands that reviewers and collaborators resist the temptation to conform to dominant perspectives. Failing to do so transforms peer review from a protective mechanism into a biased endorsement, eroding the integrity of the process and violating professional codes of ethics.

Strategies to Counteract Bias in Collaboration

To uphold ethical responsibility, engineering teams must adopt practices that actively counter confirmation bias. These may include structured review checklists, anonymous input mechanisms, and the inclusion of diverse perspectives. Encouraging dissent and rewarding critical analysis can also



strengthen team integrity. Independent verification by outside experts provides an additional layer of objectivity, ensuring that bias within a team does not compromise outcomes.

Summary

When peer review and collaboration are distorted by confirmation bias, the safeguards of engineering practice are weakened. Instead of protecting against error, they can inadvertently magnify it. Recognizing this risk is essential for engineers to fulfill their ethical obligation of independence, honesty, and objectivity in professional collaboration.

The next chapter will address conflict of interest, client pressure, and ethical blind spots, examining how external forces amplify confirmation bias and challenge ethical integrity in engineering practice.



Chapter 11: Conflict of Interest, Client Pressure, and Ethical Blind Spots



Engineering is often practiced within a web of client expectations, contractual obligations, financial pressures, and organizational politics. While these factors are normal in professional practice, they can amplify the influence of confirmation bias and create ethical blind spots.

When engineers face conflicts of interest or external pressure to deliver favorable outcomes, the risk of biased judgment increases significantly. Ethical responsibility requires resisting these pressures, yet history shows that such pressures often distort professional objectivity.

Conflict of Interest and Objectivity

A conflict of interest arises when personal, financial, or organizational incentives interfere with an engineer's ability to act impartially. In such situations, confirmation bias can serve as a psychological justification for compromised decisions. For example, an engineer who holds financial interest in a supplier may unconsciously interpret data to favor that supplier's product, rationalizing that the choice is technically sound. Even if unintentional, such behavior violates ethical principles by subordinating professional judgment to personal gain.



Client and Employer Pressure

Engineers often work under pressure from clients or employers who prioritize cost savings, deadlines, or public image. These pressures can lead engineers to unconsciously align their conclusions with client expectations, selectively emphasizing data that supports project continuation while minimizing risks. This form of confirmation bias may not feel like dishonesty to the engineer at the time, because the mind naturally seeks to justify the path of least resistance. However, the ethical breach is clear: engineers are required to protect public safety even when doing so conflicts with client wishes.

Ethical Blind Spots

Blind spots occur when engineers fail to recognize their own susceptibility to bias or pressure. These are particularly dangerous because they create the illusion of objectivity while bias is already at work. An engineer who believes “I am always objective” is often at the highest risk of unconscious distortion. Ethical humility requires recognizing one’s vulnerability to bias and adopting measures to counteract it, such as independent peer review or external audits.

Case Example: The Ford Pinto Controversy

In the 1970s, Ford Motor Company faced public outrage when it was revealed that design flaws in the Pinto’s fuel system created a high risk of fire in rear-end collisions.

Internal documents showed that company decision-makers downplayed the risk, influenced by cost-benefit analyses that prioritized financial considerations over safety. Confirmation bias allowed engineers and managers to interpret crash data in ways that supported continued production.

The ethical lapse was profound: cost pressures and corporate loyalty were allowed to overshadow the duty to protect public welfare.

The Ethical Standard

Professional engineering codes make clear that the duty to the public outweighs obligations to clients or employers. Engineers must disclose conflicts of interest, resist undue pressure, and refuse to approve work that compromises safety or misrepresents data. Ethical responsibility demands transparency, even when it is professionally inconvenient.



Counteracting Blind Spots

Practical steps to guard against these influences include establishing clear conflict-of-interest policies, fostering organizational cultures that encourage dissent, and instituting independent review mechanisms. Engineers should also develop personal awareness of how external pressures can influence perception, reminding themselves that ethical integrity may at times require difficult conversations with clients, employers, or colleagues.

Summary

Conflicts of interest, client pressure, and ethical blind spots magnify confirmation bias by reinforcing motivations to see only what is convenient. Ethical engineering practice requires recognizing these forces and counteracting them with transparency, independence, and an unwavering commitment to public safety.

The next chapter will examine whistleblowing and ethical responsibility in the presence of bias, focusing on the duty of engineers to act when they witness unethical practices fueled by biased decision-making.



Chapter 12: Whistleblowing and Ethical Responsibility in the Presence of Bias

Whistleblowing refers to the act of reporting unethical, unsafe, or unlawful practices when they threaten public safety or violate professional integrity. For engineers, the ethical responsibility to act as whistleblowers is especially significant because their work directly impacts human lives and the environment. Confirmation bias can create situations where dangers are overlooked or minimized, making the willingness of an engineer to speak out even more critical.

The Ethical Duty to Act

Engineering codes of ethics consistently affirm that the protection of public health, safety, and welfare is paramount. When engineers observe decisions distorted by confirmation bias, such as the dismissal of disconfirming evidence or the suppression of risk data, they have an ethical duty to intervene. Remaining silent in the face of bias is not neutrality but complicity, as it allows unsafe conditions to persist unchallenged.

Barriers to Whistleblowing

Despite this duty, whistleblowing is often difficult. Engineers may fear retaliation, loss of employment, damaged professional relationships, or legal consequences. Organizational cultures that prioritize profit or schedule over safety may discourage dissent. In these environments, confirmation bias becomes reinforced by social and professional pressures, further discouraging individuals from challenging flawed decisions.

Case Example: The Challenger Disaster

In the Challenger Space Shuttle case, several engineers at Morton Thiokol raised concerns about the O-ring seals in low temperatures. Despite presenting evidence, they were overruled by management, who favored launch continuity.

Although the engineers attempted to fulfill their ethical duty, the organization's confirmation bias and external pressures silenced dissenting voices. The tragedy underscores the importance of engineers persisting in their responsibility to communicate risk, even when their warnings are unpopular or inconvenient.



The Ethical Blindness of Teams

When confirmation bias permeates a team or organization, ethical responsibility may shift to individuals who recognize the danger. Engineers in such situations face a dilemma: remain silent and allow bias-driven decisions to proceed, or escalate their concerns outside normal channels. Ethical standards clearly support the latter course when public safety is at stake, even if it involves personal or professional sacrifice.

Mechanisms for Ethical Reporting

Professional organizations and regulatory boards provide pathways for ethical reporting. Many states protect licensed engineers who refuse to approve unsafe work or who report ethical violations. Whistleblowers may also report to government agencies, oversight boards, or in extreme cases, the public. While these steps are difficult, they reflect the engineer's ultimate obligation: ensuring that bias and external pressures do not endanger society.

Courage and Professional Integrity

Whistleblowing in the presence of confirmation bias requires courage. It demands that engineers resist the natural human tendency to conform, and instead act on their ethical principles even when faced with resistance. The decision to blow the whistle is not only about exposing wrongdoing but also about affirming the professional values of truth, objectivity, and responsibility that define engineering.

Summary

Whistleblowing is the ultimate safeguard against the dangers of confirmation bias. When normal checks and balances fail, the ethical responsibility falls on individuals to ensure that the public is not placed at risk by flawed or biased decisions.

The next chapter will explore decision frameworks for objectivity and ethical clarity, focusing on structured methods engineers can use to counteract bias in their professional judgment.



Chapter 13: Decision Frameworks for Objectivity and Ethical Clarity

Engineers operate in complex environments where decisions must balance technical performance, cost efficiency, environmental impact, and above all, public safety. While human judgment is indispensable, it is also susceptible to confirmation bias and other distortions.

To safeguard ethical integrity, engineers can adopt structured decision frameworks that promote objectivity and align with professional codes of conduct. These frameworks serve as tools to slow down the thought process, ensure thorough analysis, and reduce the influence of unconscious bias.

The Role of Structured Decision-Making

Structured decision frameworks provide a systematic approach to evaluating options. By requiring engineers to follow step-by-step processes rather than relying solely on intuition, these frameworks help counter the tendency to favor information that confirms preexisting beliefs. They also create documentation that can be independently reviewed, enhancing transparency and accountability.

Root Cause and Causal Analysis

One effective framework is root cause analysis, which systematically traces failures or risks back to their underlying causes. This method forces engineers to examine not only confirming evidence but also contradictory findings, thereby reducing the influence of confirmation bias.

Causal pathway analysis, a related method, maps sequences of conditions to reveal how small errors or assumptions can propagate into major failures. Both methods reinforce the ethical duty of thoroughness and honesty.

Failure Mode and Effects Analysis (FMEA)

FMEA requires engineers to systematically identify potential failure modes, assess their consequences, and assign risk priority values. Because this framework emphasizes considering multiple scenarios, including worst-case conditions, it counteracts the natural inclination to assume favorable outcomes. It ensures that decision-making aligns with the ethical responsibility to anticipate risks and safeguard public welfare.



Multi-Criteria Decision Analysis (MCDA)

MCDA introduces objectivity by requiring engineers to evaluate alternatives against a set of weighted criteria, such as cost, safety, sustainability, and reliability. By formalizing comparisons, MCDA reduces the likelihood that engineers will focus only on the data that support their preferred solution. This structured balancing of factors reflects the ethical principle of fairness, ensuring that all stakeholders' interests are considered.

Checklists and Ethical Audits

Simple but powerful tools such as checklists and ethical audits also serve as bias countermeasures. A well-designed checklist prompts engineers to ask whether disconfirming evidence has been considered, whether risk margins are sufficient, and whether data presentation is unbiased. Ethical audits extend this process by requiring reflection on how decisions align with professional codes of ethics, reinforcing the connection between technical work and ethical standards.

Independent Verification and Red Team Reviews

Another safeguard is independent verification, sometimes referred to as “red teaming.” This process assigns a separate group of engineers the task of challenging assumptions and seeking weaknesses in the proposed design. By formalizing dissent, organizations can ensure that confirmation bias within one team does not compromise the objectivity of the overall decision-making process.

Ethical Clarity through Frameworks

Decision frameworks do more than prevent technical errors; they clarify ethical responsibility. By ensuring that all evidence is considered, risks are fully evaluated, and transparency is maintained, these methods help engineers uphold their duty to protect public safety and communicate truthfully.

Summary

Structured approaches do not eliminate bias, but they limit its influence by embedding objectivity into the decision process.

The next chapter will expand on this theme by presenting techniques to detect and counteract confirmation bias at the individual level, equipping engineers with practical strategies to strengthen ethical decision-making.



Chapter 14: Techniques to Detect and Counteract Confirmation Bias

While structured frameworks provide external safeguards, engineers also need personal strategies to recognize and counteract confirmation bias in their own decision-making. Because bias often operates unconsciously, the first challenge is awareness.

Once engineers understand how confirmation bias manifests, they can adopt deliberate techniques to reduce its impact. These techniques are both practical and ethical tools, supporting objectivity and reinforcing the professional duty to protect the public.

Recognizing Warning Signs of Bias

The initial step in counteracting confirmation bias is self-awareness. Engineers should be alert to signs such as dismissing data as “outliers” without thorough investigation, feeling overly confident about a solution without testing alternatives, or disregarding peer criticism too quickly. Awareness of these behaviors can trigger a pause in decision-making, encouraging deeper reflection and review.

Actively Seeking Disconfirming Evidence

One of the most effective strategies is to deliberately search for evidence that challenges one’s own conclusions. Engineers can adopt the mindset of a “devil’s advocate,” asking: What would prove this design unsafe? What evidence would contradict my assumptions? This practice not only strengthens technical rigor but also embodies the ethical principle of honesty by ensuring that inconvenient truths are not ignored.

Considering Multiple Hypotheses

Instead of locking onto a single explanation or solution, engineers can frame multiple hypotheses and test each against available evidence. This reduces the likelihood of prematurely settling on one conclusion and filtering information to fit it. Maintaining competing hypotheses encourages fairness and broadens the scope of analysis, reinforcing the ethical obligation to evaluate all reasonable alternatives.



Checklists and Structured Reflection

Personal checklists can serve as reminders to ask critical questions: Have I considered contradictory evidence? Did I evaluate the worst-case scenario? Is my interpretation of data consistent with multiple perspectives? Embedding such questions into routine work habits prevents bias from slipping unnoticed into technical judgment.

Engaging Independent Perspectives

Bias is easier to detect when exposed to diverse viewpoints. Seeking feedback from colleagues outside the immediate project, or from those with different technical backgrounds, helps challenge assumptions. Encouraging critical feedback, rather than resisting it, strengthens both technical quality and ethical transparency.

Using Data Transparency and Documentation

Engineers can limit bias by committing to full documentation of both supporting and conflicting evidence. When data are clearly recorded and open to review, it becomes harder to suppress or rationalize unfavorable results. Transparency not only deters bias but also demonstrates ethical accountability to clients, regulators, and the public.

Slowing Down the Decision Process

Rushed decisions are particularly vulnerable to confirmation bias. Taking time to revisit assumptions, reevaluate calculations, and reflect on risks helps counter the tendency to accept conclusions too quickly. Ethical responsibility demands this diligence, especially when public safety is at stake.

Cultivating Intellectual Humility

Perhaps the most important countermeasure is humility: the recognition that no engineer is immune to bias. By accepting vulnerability to error, professionals remain open to correction and continuous learning. This humility aligns directly with ethical principles, since it acknowledges responsibility not just for personal reputation but for the broader impact of engineering decisions on society.



Summary

Together, these techniques form a toolkit that empowers engineers to identify and limit confirmation bias in practice. The next chapter will expand the focus to structured peer review and independent verification, which provide organizational safeguards to complement individual vigilance.



Chapter 15: Structured Peer Review and Independent Verification



Peer review and independent verification are essential mechanisms in engineering practice designed to ensure that technical decisions are free from unchecked assumptions and biases. While individual vigilance against confirmation bias is important, organizational safeguards are equally necessary. A structured approach to peer review and external verification strengthens the integrity of engineering work, aligning professional practice with ethical obligations to protect the public.

The Purpose of Structured Peer Review

Peer review allows designs, analyses, and reports to be examined by qualified professionals who are independent of the original work. The objective is not simply to confirm the conclusions reached by the primary team but to challenge assumptions, identify overlooked risks, and ensure that the work meets both technical and ethical standards. When carried out effectively, peer review serves as a filter that exposes confirmation bias by introducing alternative perspectives.

Independent Verification as a Safeguard

Independent verification extends beyond peer review by assigning responsibility to a separate group or organization to validate the accuracy and safety of a design. This process is especially important in high-stakes projects such as



nuclear power facilities, bridges, aerospace systems, and chemical plants, where the consequences of failure are catastrophic. Independent verification reduces the likelihood that internal biases, reinforced by groupthink, client pressure, or organizational culture, will compromise objectivity.

Avoiding Rubber-Stamping

The effectiveness of peer review depends on its independence and rigor. When review is reduced to a formality or becomes influenced by the same biases affecting the original team, the process loses value. Ethical responsibility requires reviewers to approach their role with impartiality, resisting organizational pressure to “rubber-stamp” findings. Structured processes, such as formal review checklists, standardized documentation, and mandatory sign-off by independent parties, help prevent superficial or biased review.

Case Example: Boston’s Big Dig

During the Central Artery/Tunnel Project in Boston, multiple design and construction issues arose, including the collapse of ceiling panels in 2006 that killed a motorist. Investigations revealed deficiencies in oversight and review processes. Engineers failed to adequately question material and anchoring decisions, allowing unsafe practices to persist.

This case underscores the ethical cost of inadequate verification and the need for structured, independent review that resists the distortions of confirmation bias.

Encouraging a Culture of Challenge

Peer review and independent verification succeed best in a professional culture that values dissent and encourages open questioning. Ethical leadership is critical to create environments where reviewers are free to challenge assumptions without fear of reprisal. Establishing review protocols that explicitly require the consideration of disconfirming evidence ensures that critical risks are not ignored.

Ethical Alignment of Verification

These safeguards are not just technical quality-control measures; they are expressions of the engineer’s ethical obligation to safeguard public health, safety, and welfare. By embedding independence into the review process, engineers demonstrate their commitment to objectivity, honesty, and accountability.



Summary

Structured peer review and independent verification serve as the external checks that balance the internal biases of individual engineers and teams. Together, they reinforce ethical standards and help prevent catastrophic failures rooted in flawed or biased judgment.

The next chapter will explore ethics in adopting emerging technologies under uncertainty, where confirmation bias often leads to premature enthusiasm or unwarranted resistance, challenging engineers to balance innovation with responsibility.



Chapter 16: Ethics in Adopting Emerging Technologies under Uncertainty

Engineering progress often depends on the adoption of new technologies. Innovations in materials, energy systems, digital modeling, artificial intelligence, and biotechnology have transformed engineering practice. Yet with every advancement comes uncertainty, both in performance and in long-term consequences.

Confirmation bias can strongly influence how engineers and organizations evaluate these uncertainties, either by overestimating the benefits of a new technology or by underestimating the risks it may carry. From an ethical perspective, engineers must navigate this tension with care, balancing innovation with the duty to protect public health, safety, and welfare.

Premature Enthusiasm and Bias

When new technologies are introduced, there is often a rush to embrace them based on early successes, marketing claims, or optimism about their potential. Engineers may unconsciously highlight data that supports adoption while minimizing evidence of limitations or risks. This form of bias is particularly dangerous because it can lead to large-scale implementation before adequate testing has been completed.

History shows that many technologies once believed to be safe and revolutionary, such as asbestos insulation, later revealed serious hazards. Ethical responsibility requires engineers to temper enthusiasm with skepticism, ensuring that adoption decisions are based on comprehensive evaluation rather than selective evidence.

Resistance to Innovation

The opposite form of confirmation bias occurs when engineers are overly skeptical of emerging technologies and cling to familiar practices. Engineers may interpret data in ways that reinforce their belief in traditional methods, ignoring evidence that new technologies could improve safety, sustainability, or efficiency. Such resistance can also be ethically problematic, as it deprives society of potential benefits.



Ethical responsibility requires engineers to evaluate innovation with fairness, giving proper weight to both advantages and risks.

Uncertainty and the Precautionary Principle

Emerging technologies often involve unknowns that cannot be fully resolved before adoption. In such cases, the precautionary principle serves as an ethical guide, emphasizing caution when uncertainty poses potential risks to health, safety, or the environment. Confirmation bias can distort the application of this principle: engineers may downplay risks because they conflict with the desire for innovation or profitability.

Maintaining ethical clarity requires acknowledging uncertainties openly and avoiding the temptation to present incomplete knowledge as certainty.

Case Example: Self-Driving Vehicles

The rapid development of autonomous vehicles illustrates these challenges. Early testing demonstrated remarkable promise, but accidents during trials revealed limitations in sensor reliability and algorithmic decision-making.

Companies and engineers promoting the technology faced ethical questions about whether their enthusiasm overshadowed the duty to protect public safety. A balanced approach required engineers to disclose risks transparently, adopt gradual implementation strategies, and engage in rigorous independent testing before wide-scale deployment.

The Ethical Balance

Adopting new technologies is not inherently unethical, but doing so without objectivity and transparency is. Engineers must present both benefits and risks, avoid overstating certainty, and resist pressures, whether from clients, employers, or public excitement, that bias evaluations. Ethical practice requires fairness: giving innovation due consideration while ensuring that uncertainties are not ignored or concealed.

Summary

Ultimately, the ethical question is not whether to adopt emerging technologies, but how to do so responsibly. By acknowledging uncertainty, actively seeking disconfirming evidence, and employing independent review, engineers can reduce the influence of confirmation bias and ensure that new technologies are introduced in a way that protects society.



The next chapter will examine the role of professional societies and licensing boards in upholding objectivity, exploring how institutional standards and oversight help counteract the risks posed by bias in individual and organizational decision-making.



Chapter 17: The Role of Professional Societies and Licensing Boards in Upholding Objectivity

Professional societies and licensing boards play a critical role in reinforcing ethical standards and guarding against the influence of confirmation bias in engineering practice. While individual engineers must cultivate personal vigilance, institutional frameworks provide the structure, accountability, and oversight needed to maintain objectivity across the profession. These organizations not only establish codes of ethics but also serve as enforcers of standards that protect the public and preserve trust in the engineering profession.

Professional Societies as Ethical Guides

Organizations such as the National Society of Professional Engineers (NSPE), the American Society of Civil Engineers (ASCE), the Institute of Electrical and Electronics Engineers (IEEE), and others publish codes of ethics that emphasize objectivity, honesty, and the primacy of public welfare. These codes explicitly require engineers to base their professional judgments on objective data and to avoid misrepresentation. By formally identifying these principles, societies provide a professional compass to guide engineers in resisting bias, even when subtle psychological tendencies or external pressures encourage selective reasoning.

Licensing Boards and Legal Enforcement

State licensing boards carry the authority to enforce ethical and professional standards through regulation. Engineers found guilty of unethical practices, such as concealing risk data, misrepresenting test results, or allowing client pressure to override safety concerns, can face fines, license suspension, or permanent revocation. This legal authority reinforces the obligation to resist confirmation bias, reminding engineers that biased decision-making is not only a cognitive flaw but also a potential violation of licensure law.

Promoting Objectivity through Continuing Education

Both professional societies and licensing boards emphasize continuing education as a safeguard against bias. Regular exposure to updated standards, case studies, and best practices helps engineers avoid stagnation and reduces



the likelihood of relying on outdated assumptions that reinforce bias. Continuing education also fosters self-awareness, equipping professionals to identify subtle distortions in their own judgment.

Independent Review Standards

Societies and boards often require independent verification or third-party review for projects of significant public impact, such as bridges, power plants, or environmental systems. By formalizing this process, institutions embed objectivity into engineering practice, ensuring that confirmation bias within a single team does not go unchecked.

Case Example: Post-Failure Investigations

After major engineering failures, professional societies and boards often lead investigations that identify not only technical causes but also ethical lapses. For instance, after the Hyatt Regency walkway collapse, professional reviews highlighted the failure of independent scrutiny and communication.

These inquiries serve as reminders that bias-driven errors can be both preventable and subject to professional accountability.

Institutional Culture and Ethics

Beyond regulation, professional organizations shape the culture of engineering practice by rewarding integrity and transparency. Awards for ethical leadership, publication of case studies on ethical dilemmas, and forums for open discussion all help normalize the expectation that engineers must recognize and resist cognitive biases.

Summary

Professional societies and licensing boards provide the ethical scaffolding that supports individual engineers in maintaining objectivity. Their codes, regulations, and educational programs institutionalize the profession's commitment to honesty, fairness, and public protection. By reinforcing the dangers of bias and establishing accountability, these bodies ensure that ethical responsibility is not left solely to individual judgment but is upheld as a collective professional standard.

The next chapter will broaden the perspective by examining cross-disciplinary lessons from medicine, law, and aviation ethics, fields where bias and ethical decision-making also play decisive roles in safeguarding human welfare.



Chapter 18: Cross-Disciplinary Perspectives – Medicine, Law, and Aviation Ethics Lessons for Engineers

The ethical challenges posed by confirmation bias are not unique to engineering. Other high-stakes professions, such as medicine, law, and aviation, also grapple with the tension between human judgment and objectivity. These fields have developed safeguards, cultural norms, and professional practices to counteract bias, and their experiences offer valuable lessons for engineers.

Medicine: Diagnostic Errors and Bias

In medicine, confirmation bias frequently appears in the diagnostic process. Physicians may form an early hypothesis about a patient's condition and unconsciously interpret test results to support it, dismissing evidence that suggests alternative diagnoses.

This phenomenon, sometimes called “**diagnostic anchoring**,” can delay proper treatment and endanger patients. To counteract it, the medical profession emphasizes differential diagnosis, deliberately considering multiple possible conditions until evidence narrows the field. For engineers, this mirrors the ethical need to explore multiple design alternatives and test competing hypotheses, rather than locking onto a single favored solution.

Law: Advocacy versus Objectivity

Attorneys, by their role, are advocates for a particular client or cause, but judges and legal scholars emphasize the importance of objectivity. In the courtroom, confirmation bias can distort the interpretation of evidence, leading to miscarriages of justice. Legal ethics demand that attorneys disclose material facts and that judges carefully evaluate both supporting and opposing arguments. Engineers can learn from this by recognizing that advocacy for a design or solution must never override the responsibility to present all material evidence, including disconfirming data, truthfully and transparently.

Aviation: Checklists and Safety Culture

In aviation, confirmation bias has contributed to accidents when pilots or crews disregarded warning signals because they did not fit their expectations. To counter this, aviation developed rigorous safety cultures centered on checklists,



standard operating procedures, and crew resource management (CRM). CRM, in particular, trains flight crews to communicate openly, challenge assumptions, and encourage even junior members to question decisions when safety is at stake. For engineers, adopting similar practices, structured peer review, checklists, and a culture that encourages open dissent, can provide powerful safeguards against bias-driven errors.

Shared Ethical Principles

Across medicine, law, and aviation, a common theme emerges: bias is inevitable, but professions can design systems to limit its influence. Differential diagnosis in medicine, evidentiary balance in law, and procedural discipline in aviation all reflect structured methods to ensure objectivity. Each field emphasizes transparency, fairness, and the protection of human welfare, principles that align directly with the ethical obligations of engineers.

Lessons for Engineers

The key lesson for engineering is that ethics cannot rely solely on individual willpower or intention. Just as medicine, law, and aviation embed safeguards into their professional practices, engineering must institutionalize processes, peer review, independent verification, checklists, and ethical audits, that actively counteract bias.

Summary

By learning from other fields, engineers strengthen both technical reliability and ethical integrity, ensuring that their duty to society is consistently fulfilled. The next chapter will return to the individual dimension of ethics by examining the development of ethical self-awareness and professional humility, qualities that help engineers recognize bias and uphold objectivity in their daily practice.



Chapter 19: Developing Ethical Self-Awareness and Professional Humility

Ethical self-awareness and professional humility are essential traits for engineers seeking to uphold objectivity and resist the influence of confirmation bias. While technical expertise provides the foundation for sound engineering practice, it is self-awareness that enables professionals to recognize their own cognitive limitations. Without this recognition, even the most skilled engineers risk allowing unconscious biases to distort judgment, creating ethical vulnerabilities that compromise public safety.

The Nature of Ethical Self-Awareness

Ethical self-awareness involves the conscious recognition that one's decisions may be influenced by personal beliefs, assumptions, and biases. It requires engineers to question not only their data and calculations but also their own reasoning processes.

For example, when an engineer feels unusually confident about a conclusion despite limited testing, self-awareness prompts them to ask: Am I interpreting this evidence fairly, or am I seeking confirmation of what I already believe? This act of reflection transforms bias from an invisible influence into a challenge that can be consciously addressed.

The Role of Professional Humility

Professional humility complements self-awareness by fostering openness to correction and alternative perspectives. Engineers who assume their expertise makes them immune to error are at the highest risk of confirmation bias. By contrast, humility encourages engineers to acknowledge uncertainty, listen to dissenting opinions, and accept that even experienced professionals can overlook critical evidence.

Far from weakening credibility, humility strengthens professional integrity by aligning engineers with the ethical obligation to present truth, not personal pride.



Case Example: Tacoma Narrows Bridge (1940)

The collapse of the Tacoma Narrows Bridge illustrates how a lack of humility can magnify bias. Engineers at the time underestimated the effects of wind-induced oscillations, dismissing warnings about aerodynamic instability. Their confidence in traditional suspension bridge design overshadowed evidence of potential failure. Greater humility might have prompted more rigorous testing and consideration of alternative models, potentially preventing the collapse.

Practical Strategies for Cultivating Self-Awareness

Developing self-awareness and humility requires deliberate effort. Reflection journals, ethical audits, and post-project evaluations can help engineers examine not just technical outcomes but also their decision-making processes. Mentorship and peer feedback also encourage humility by exposing professionals to alternative viewpoints. Finally, engaging with case studies of past engineering failures reinforces the importance of vigilance against bias.

Ethical Alignment

Both self-awareness and humility are deeply tied to ethical obligations. Engineers are entrusted with decisions that affect lives, and this trust demands honesty not only with others but also with oneself. Recognizing one's susceptibility to bias and welcoming correction is an act of ethical responsibility. It demonstrates commitment to the principle that the welfare of the public must take precedence over personal ego or convenience.

Summary

Ethical self-awareness and professional humility are thus not optional virtues; they are essential components of responsible engineering practice. By cultivating these traits, engineers strengthen their ability to detect confirmation bias and maintain the objectivity necessary to fulfill their duty to society. The next chapter will conclude the course with a discussion on cultivating ethical objectivity in engineering practice, bringing together the themes of bias awareness, ethical responsibility, and professional safeguards.



Chapter 20: Conclusion – Cultivating Ethical Objectivity in Engineering Practice

Engineering is more than the application of mathematics and science to solve technical problems. It is a profession built on public trust, with ethical obligations that extend beyond the engineer's immediate employer or client. Central to this duty is the requirement to make decisions objectively, free from distortions that compromise accuracy and safety. Confirmation bias, as one of the most persistent cognitive tendencies, threatens this objectivity at every stage of engineering practice.

Throughout this course, the relationship between ethics and bias has been examined across multiple dimensions. Engineers have a duty to protect public health, safety, and welfare; however, this duty can be undermined if problems are defined in ways that favor preconceived solutions, if testing data are selectively interpreted, or if peer review devolves into groupthink. Ethical failures often begin not with overt dishonesty but with unconscious biases left unrecognized and unchecked.

The case studies explored in previous chapters illustrate how catastrophic failures, whether in bridges, buildings, environmental systems, or aerospace, are rarely the result of a single technical miscalculation. More often, they are the outcome of biased judgment combined with organizational or cultural pressures. In each instance, engineers faced ethical choices: to confront uncomfortable evidence or to accept reassuring narratives. When bias prevailed, the consequences were measured in lives lost, communities harmed, and public trust eroded.

Yet the presence of bias need not guarantee failure. Engineers can cultivate ethical objectivity through a combination of personal and institutional safeguards. On the individual level, developing self-awareness, intellectual humility, and a willingness to seek disconfirming evidence strengthens professional judgment. On the organizational level, structured peer review, independent verification, and transparent reporting serve as counterbalances to bias. Professional societies and licensing boards reinforce these safeguards by codifying ethical standards, mandating continuing education, and holding engineers accountable for their decisions.

Perhaps the most important lesson is that objectivity is not a passive state but an active discipline. Engineers must continually question assumptions, embrace



diverse perspectives, and resist pressures that encourage selective reasoning. By doing so, they not only fulfill their technical responsibilities but also their ethical mandate to place the welfare of the public above all other considerations.

In conclusion, cultivating ethical objectivity is a lifelong professional responsibility. Confirmation bias can never be entirely eliminated, but it can be managed through vigilance, reflection, and structured practices. Engineers who commit to this discipline honor both the scientific foundations of their field and the ethical trust placed in them by society. By uniting technical rigor with ethical awareness, engineers can ensure that their work stands as a safeguard of safety, integrity, and public welfare.



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