

WHAT ARE WE MISSING?

SOURCES AND NOTES

The complete chapter endnotes and reference lists,
as they appear in the print edition

594 notes across 15 chapters

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CHAPTER 1

The Foundations of Critical Thinking

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The Machinery of Thinking

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The Bugs in the Machinery

Notes

1. New York Times (2015), 'Theranos, Facing Criticism, Says It Has Changed Board Structure', 29 October. The board was "notably lacking in people with expertise in medical testing"; members included Kissinger, Shultz, Nunn, Frist, a retired general and a retired admiral.
2. Walgreen Co. v. Theranos, Inc. (D. Del., 2016), case 1:16-cv-01040: the court record documents a \$100 million innovation fee, paid under a December 2013 amendment to the Master Services Agreement, and a \$40 million convertible note, the components behind the \$140 million figure in the prose and the \$140 million lawsuit. MedCity News (2016).
3. MarketWatch (2015), 'Safeway looks to sever ties with Theranos after \$350 million spend': about \$350 million building clinics in more than 800 stores; the testing service never launched.
4. The 31,000 figure is Theranos's own admission: Walgreen Co. v. Theranos, Inc., complaint (D. Del., 2016), alleging that Theranos admitted on 11 June 2016 that 31,000 reports, more than 10% of those delivered to Walgreens customers, were voided. The wider picture: the Wall Street Journal reported "tens of thousands" of corrected reports covering every proprietary test from 2014-2015, and Theranos's replacement lab director estimated about 50,000 (order in R.G. v. Theranos, N.D. Cal., 4:16-cv-02891).
5. Restitution order, US v. Holmes and Balwani (N.D. Cal.): Holmes convicted by a jury on 3 January 2022; Balwani convicted in July 2022; joint restitution of \$452,047,268 ordered.
6. Carreyrou (2018). The investigation began with whistleblowers and former employees; the book documents the legal threats against them and the availability of warning evidence.
7. Tversky and Kahneman (1974), the founding statement of the heuristics-and-biases programme: representativeness, availability, and anchoring with insufficient adjustment.
8. Mercier and Sperber (2017). The interactionist account: reasoning's primary function is argumentative and social, which explains the persistence of biases such as myside bias.
9. Stanovich and West (2008), Journal of Personality and Social Psychology, 94(4), pp. 672-695: across seven studies, many classic biases (framing, anchoring, base-rate neglect, sunk cost, myside bias) were uncorrelated with cognitive ability; a smaller set did correlate. The dysrationalia argument is developed in Stanovich (2009).

10. Kahneman and Frederick (2002). Attribute substitution: a difficult target question is answered via an easier heuristic attribute, outside awareness.
11. Morewedge et al. (2015), *Policy Insights from the Behavioral and Brain Sciences*, 2(1), pp. 129-140. A single training game or video produced immediate bias reductions (games at least 31.94%, videos at least 18.60%) persisting at least two months (games at least 23.57%).
12. Dharanikota et al. (2024), *Human Factors*. Eighty articles, 100 debiasing investigations, 91 biases; strategies classed as information design, procedural debiasing, and group structure; most reportedly effective, 14 ineffective, 6 partially effective.
13. Dell'Acqua et al. (2023), *Harvard Business School Working Paper 24-013*: a preregistered field experiment with 758 consultants; inside the frontier, AI users completed more tasks, about 25 per cent faster, at higher rated quality; on the task outside the frontier, AI users were 19 per cent less likely to reach the correct answer.
14. Gerlich (2025), *Societies*, 15(1), 6: a mixed-methods study of 666 participants; frequent AI tool use correlated negatively with critical-thinking scores, with cognitive offloading as the mediating factor. Correlational, one study; a correction to the paper followed on 10 September 2025 (*Societies*, 15(9), 252), and its method has drawn public criticism.
15. Kosmyrna et al. (2025), 'Your Brain on ChatGPT', arXiv:2506.08872 (preprint, not peer-reviewed): 54 participants across LLM, search-engine and unaided writing conditions; the LLM group showed the weakest measured brain engagement and the least ownership, and could not reliably quote their own essays; under-engagement persisted in the 18 participants who then wrote unaided.
16. Mollick (2024), *Co-Intelligence: Living and Working with AI: the human-in-the-loop rules for AI-assisted work*.
17. Cialdini (2007), the authority principle: deference to symbols of authority, strongest under uncertainty and unfamiliarity.
18. Arkes and Blumer (1985), *Organizational Behavior and Human Decision Processes*, 35(1), pp. 124-140: the sunk cost effect demonstrated experimentally.
19. Carreyrou (2018): the miniaturised Edison devices failed internal validation, and most tests were quietly run on adapted commercial machines.
20. Janis (1972), *Victims of Groupthink*: in cohesive, prestigious groups, concurrence-seeking overrides realistic appraisal, and dissent reads as disloyalty. Janis's cases were foreign-policy fiascoes; the framework fits any prestige-sealed room.
21. Carreyrou (2018) documents the internal-to-regulator sequence. The family pressure is on the record in Shultz's own words: Amanpour and Company, PBS, 7 August 2020, whose published transcript records host Hari Sreenivasan putting to Shultz that his grandfather seemed 'to be picking the version of reality that Elizabeth

Holmes was presenting to him' over his grandson's warnings (video and transcript at pbs.org/wnet/amanpour-and-company/video/this-whistleblower-exposed-theranos-life-threatening-ruse/). Shultz raised concerns internally, then to regulators; his grandfather sided with Holmes, and the relationship broke.

22. Dalio (2017); CNBC Make It (2019), 'Billionaire Ray Dalio on his biggest mistake', 4 December, Dalio's own first-person essay: wrong on the 1982 debt crisis, broke, borrowed \$4,000 from his father (<https://www.cnbc.com/2019/12/04/billionaire-ray-dalio-was-once-broke-and-borrowed-money-from-his-dad-to-pay-family-bills.html>).
23. Dalio (2017). Decision logs, believability-weighted voting, radical transparency and structured dissent are described there as Bridgewater's operating system. The account is the founder's own and is presented as such in the text.
24. US Senate Select Committee on Intelligence (2004), Report on the U.S. Intelligence Community's Prewar Intelligence Assessments on Iraq, 9 July: the inquiry's account of analysis locked onto the prevailing assumption, with alternatives undertested.
25. CIA, Center for the Study of Intelligence (2009), A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis: the codification, including Analysis of Competing Hypotheses, devil's advocacy and Team A/Team B.
26. Reuters (2022), 'Crypto exchange FTX valued at \$32 bln as SoftBank invests', 31 January: the \$400 million round included SoftBank, Temasek and the Ontario Teachers' Pension Plan; Sequoia Capital was an earlier investor.
27. Sequoia Capital's own editor's note: profile of Bankman-Fried published 22 September 2022, removed 10 November 2022; FTX filed for Chapter 11 on 11 November 2022. The profile survives in the Internet Archive (capture of 27 October 2022, <https://web.archive.org/web/20221027180943/https://www.sequoiacap.com/article/sam-bankman-fried-spotlight/>).
28. Reuters (2022), 'FTX's founder dismisses balance-sheet concerns as false rumors', 7 November: the posts of 7 November 2022, later deleted; FTX filed for Chapter 11 on 11 November.
29. Caroline Ellison's guilty-plea allocution, S.D.N.Y., hearing of 19 December 2022, unsealed 23 December; transcript pp. 27-28, docket document 19, case 1:22-cr-00673-LAK, public copy via CourtListener (https://storage.courtlistener.com/recap/gov.uscourts.nysd.591465/gov.uscourts.nysd.591465.19.0_1.pdf): she stated that from 2019 she understood Alameda's negative balances meant it was borrowing funds FTX's customers had deposited, and that 'we prepared certain quarterly balance sheets that concealed the extent of Alameda's borrowing'.
30. AP (2023), 'Sam Bankman-Fried trial: FTX founder convicted of fraud': convicted 2 November 2023 for stealing at least \$10 billion from customers and investors.

31. US Department of Justice (2024): Bankman-Fried sentenced to 25 years, 28 March 2024.
32. Kunda (1990), *Psychological Bulletin*, 108(3), pp. 480-498: motivated reasoning; directional goals shape the strategies of reasoning and the conclusions reached.
33. Merritt, Effron and Monin (2010), *Social and Personality Psychology Compass*, 4(5), pp. 344-357: moral self-licensing, past good behaviour licensing later relaxed standards.
34. Blanken, van de Ven and Zeelenberg (2015), *Personality and Social Psychology Bulletin*, 41(4), pp. 540-558: a meta-analysis of 91 studies with 7,397 participants estimates the licensing effect at Cohen's $d = 0.31$, with published studies showing larger effects than unpublished ones. Against that estimate: Blanken, van de Ven, Zeelenberg and Meijers (2014), *Social Psychology*, 45(3), pp. 232-238, three high-powered replications, total $N = 1,195$, none confirming the effect; Urban, Bahník and Braun Kohlová (2019), *Journal of Environmental Psychology*, 63, pp. 139-147, three further attempts in the pro-environmental domain, also not finding it; and Kuper and Bott (2019), *Meta-Psychology*, 3, a publication-bias reanalysis of the meta-analytic data adjusting the effect to $d = 0.18$ on one method and below zero on another.
35. Koriati, Lichtenstein and Fischhoff (1980), *Journal of Experimental Psychology: Human Learning and Memory*, 6(2), pp. 107-118: generating opposing reasons reduces overconfidence.
36. Heuer (1999), *Psychology of Intelligence Analysis*, CIA Center for the Study of Intelligence: analyst mind-set as the failure point; Analysis of Competing Hypotheses as engineered consider-the-opposite.
37. Klein (2007), 'Performing a Project Premortem', *Harvard Business Review*, September.
38. Mitchell, Russo and Pennington (1989), *Journal of Behavioral Decision Making*, 2(1), pp. 25-38: prospective hindsight; explanations for stipulated outcomes are longer and richer in episodic reasons. The "about 30%" figure is Klein's summary of this research in note 37 and is attributed to him in the text.
39. Kahneman and Tversky (1973), *Psychological Review*, 80(4), pp. 237-251; Bar-Hillel (1980), *Acta Psychologica*, 44(3), pp. 211-233. The planning fallacy and the outside view are developed for a general reader in Kahneman (2011).
40. Flyvbjerg (2014), 'What You Should Know About Megaprojects and Why: An Overview', *Project Management Journal*, 45(2), pp. 6-19: nine out of ten megaprojects over budget; overruns of up to 50% in real terms common; the record stable across 70 years and geographies. The four-part "iron law" (over budget, over time, under benefits, over and over again) is from Flyvbjerg and Gardner (2023); the 2014 paper states the three-part version.
41. Frohlich and Oppenheimer (1992). Behind a veil, groups reached consensus but rejected maximin, converging on maximising average income with a floor

constraint.

42. Huang et al. (2019), 'Veil-of-ignorance reasoning favors the greater good', PNAS, 116(48): seven experiments, $n = 6,261$; veil reasoning produced more impartial, greater-good choices, unexplained by anchoring or generic perspective-taking.
43. Reuters (2018), 'Amazon scraps secret AI recruiting tool that showed bias against women', 10 October: the engine, trained on ten years of CVs, penalised women's applications; Amazon abandoned it.
44. Regulation (EU) 2024/1689 (the AI Act), Annex III: AI systems used in recruitment and employment decisions are classified high-risk.
45. Gawande (2009), *The Checklist Manifesto*.
46. Haynes et al. (2009), 'A Surgical Safety Checklist to Reduce Morbidity and Mortality in a Global Population', *New England Journal of Medicine*, 360(5): deaths 1.5% to 0.8% ($P = 0.003$), complications 11.0% to 7.0% ($P < 0.001$), eight hospitals, 3,733 then 3,955 patients.
47. Urbach et al. (2014), 'Introduction of Surgical Safety Checklists in Ontario, Canada', *New England Journal of Medicine*, 370(11), pp. 1029-1038: across 101 hospitals, checklist adoption was not associated with significant reductions in operative mortality or complications.
48. Moore and Healy (2008), *Psychological Review*, 115(2), pp. 502-517.
49. Tetlock and Gardner (2015). *The forecasting-tournament evidence: scoring predictions, reviewing misses and updating distinguishes the consistently improving forecasters*.
50. Edmondson (2018). *Psychological safety, the belief that speaking up will not be punished, predicts error reporting and team learning*.

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R.G. v. Theranos, Inc. (N.D. Cal., 4:16-cv-02891), order on corrected and voided blood-test reports; Walgreen Co. v. Theranos, Inc. (D. Del., 2016), complaint.

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REPORTS AND BROADCASTS

What the Machine Eats

Notes

1. Giles (2005), *Nature*, 438, pp. 900-901: 42 pairs of science entries reviewed blind by experts; Wikipedia averaged around four inaccuracies per entry, Britannica around three. Britannica disputed the method and the findings; the comparison covered science entries only, so it shifted the burden of proof rather than settling the argument.
2. U.S. Senate Select Committee on Intelligence (2019), Report Volume 2 (October 2019): Russia's use of social media in the 2016 election. The 126-million figure is Facebook's own estimate to Congress. The twin Houston protests of May 2016 were documented in the February 2018 federal indictment of IRA operatives and aired publicly at a November 2017 hearing, two years before this report appeared.
3. NewsGuard, Tracking AI-enabled Misinformation (running tracker): dozens of AI-generated news sites when tracking began in 2023; more than 3,700 at the time of writing, across more than a dozen languages.
4. World Economic Forum (2025), Global Risks Report 2025: misinformation and disinformation ranked the most severe global risk over the two-year horizon for the second consecutive year, drawing on around 900 surveyed experts and leaders.
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6. Vosoughi, Roy and Aral (2018), *Science*, 359, pp. 1146-1151: roughly 126,000 true and false rumour cascades on Twitter, 2006-2017, spread by about three million people; falsehood diffused significantly farther, faster, deeper and more broadly than the truth, and the truth took about six times as long to reach 1,500 people. Bots accelerated true and false news equally; the asymmetry came from human sharing.
7. Gentzkow and Shapiro (2011), *Quarterly Journal of Economics*, 126(4), pp. 1799-1839: measured ideological segregation of Americans' online and offline news diets; online segregation was real but modest, and lower than in face-to-face networks.
8. Dubois and Blank (2018), *Information, Communication & Society*, 21(5), pp. 729-745: 'The echo chamber is overstated'; people with varied media diets and an interest in politics regularly encounter opposing views.
9. Bandy and Diakopoulos (2020), *ICWSM*, 14(1), pp. 36-47: an audit of Apple News finding curation dominated by opaque algorithmic systems; Anspach and Carlson (2020), *Political Behavior*, 42, pp. 697-718: belief in misinformation is widespread, and corrective social-media commentary reduces it only partially.

10. Gorwa, Binns and Katzenbach (2020), *Big Data & Society*, 7(2): content moderation at platform scale, its increasing automation, and its political limits.
11. *Mata v. Avianca, Inc.*, 1:22-cv-01461 (S.D.N.Y., opinion and order on sanctions, docket entry 54, 22 June 2023): two lawyers sanctioned after filing a brief citing six non-existent decisions generated by a chatbot and never verified; the order records their continuing to stand by the fake opinions after the court questioned them.
12. Dahl et al. (2024), *Journal of Legal Analysis*, 16, pp. 64-93: the paper's own abstract states that leading models hallucinated at least 58 per cent of the time across its legal tasks, varying by model and task, and struggled to predict their own hallucinations. A 2024 legal-task result, not today's general chatbot error rate.
13. Couldry and Mejias (2024): the extraction of behavioural data as a new form of colonial appropriation, its asymmetries falling hardest on those least equipped to resist.
14. Gigerenzer (2002): relative versus absolute risk; the '50 per cent increase' example is the book's signature illustration of how relative figures inflate alarm and reassurance alike.
15. Charig et al. (1986), *BMJ*, 292, pp. 879-882: open surgery versus percutaneous nephrolithotomy for kidney stones; the pooled ranking reversed within each stone-size group, the standard clinical demonstration of Simpson's paradox. Table 4.2's pooled rates are from the paper's own abstract (78% and 83%); the subgroup counts (81/87, 234/270, 192/263, 55/80) are as tabulated by Julious and Mullee (1994), *BMJ*, 309, p. 1480, with percentages recomputed from those counts (their printed 83% for the 234/270 cell is an arithmetic slip; the table prints the computed 87%).
16. Bickel, Hammel and O'Connell (1975), *Science*, 187, pp. 398-404: Berkeley graduate admissions; the apparent aggregate bias against women largely vanished department by department, driven by application patterns across departments of differing competitiveness.
17. Cairo (2019): a field guide to misleading charts, truncated axes, selective time windows, dual y-axes, and the discipline of reading the axes before the shape.
18. Goldman (2001), *Philosophy and Phenomenological Research*, 63(1), pp. 85-110: the novice's problem, how to decide which experts to trust when you cannot evaluate the evidence yourself.
19. Wineburg and McGrew (2019), *Teachers College Record*, 121(11): ten professional fact-checkers reached sound verdicts quickly on live website-evaluation tasks, reading laterally, while ten historians and 25 undergraduates reading vertically were frequently taken in. Small samples; a study of expertise, not a population estimate.
20. Brodsky et al. (2023), *AERA Open*, 9: Canadian secondary students' use of lateral-reading strategies rose from 11 per cent of the time at pretest to 59 per cent

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27. Tetlock (2005): 284 experts and over 82,000 forecasts tracked over twenty years; average expert accuracy barely beat chance, and the most confident single-idea forecasters performed worst.
28. Chen and Magramo (2024), CNN, 4 February: Hong Kong police reported a finance worker deceived into transferring about HK\$200 million, roughly 25 million US dollars, after a video conference in which every other participant was a deepfake.
29. Associated Press (2021), 14 December: a review of potential voter-fraud cases in the six battleground states disputed by the Trump campaign found fewer than 475, a number that would have made no difference in any state.

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The Right Tool for the Job

Notes

1. Rogers Commission (1986), chapter 3 and Appendix H: the ambient air temperature at launch was 36 degrees Fahrenheit, "15 degrees colder than that of any previous launch" (chapter 3); Appendix H records a calculated O-ring temperature of 53 degrees for STS 51-C, the coldest before 51-L, and the worst blow-by of any shuttle flight. Chapter 5 records Thiokol's initial written recommendation against launch below 53 degrees, and the weather forecast projecting temperatures as low as 18 degrees in the early morning of 28 January.
2. Rogers Commission (1986), chapter 5: the first teleconference phase began at 5:45 p.m. EST, the main phase at 8:45 p.m., and the conference resumed at about 11 p.m. with Thiokol's reversed recommendation; the chapter also records Jerald Mason's instruction to Robert Lund, Thiokol's vice-president and director of engineering, to take off his engineering hat and put on his management hat, and that no engineer in the room spoke for launch before or after the management caucus.
3. Rogers Commission (1986), chapter 5, finding: "The decision to launch the Challenger was flawed."
4. Vaughan (1996): the normalisation of deviance and the reversal of the burden of proof inside NASA's decision culture.
5. Getzels and Csikszentmihalyi (1976): artists who spent longer exploring and defining the problem before executing produced work rated more original.
6. Guilford (1967): the convergent-divergent distinction; investigation fails when convergence precedes the divergent search for framings.
7. Ibn al-Haytham, al-Shukuk 'ala Batlamyus, in the Sabra and Shehaby edition (1971); the English rendering follows A. I. Sabra's translation as published in Harvard Magazine, September-October 2003. The quotation is cut at "imperfection"; the source continues "and deficiency".
8. For each tradition in this section: Aristotle, Physics, Book II (the four causes); the Canon of Ibn Sina, Book II (the rules for testing remedies); Sabra and Shehaby (1971) for Ibn al-Haytham; Wilhelm and Baynes (1967) for the Yijing; Fraser (2016) for the Mohist three tests; Griffith (1963) for Sunzi's five factors.
9. Chi, Feltovich and Glaser (1981): experts sorted problems by underlying physical principle; novices by surface features.
10. Rogers Commission (1986), chapter 6: the field joint carried primary and secondary O-rings and was classified Criticality 1R (redundant hardware) on 24 November 1980; when joint rotation was shown capable of disengaging the secondary seal

from its seat, the dual rings were judged not a completely redundant system and the classification was changed to Criticality 1, at Marshall on 17 December 1982.

11. Mitchell, Agle and Wood (1997): power, legitimacy and urgency as the attributes of stakeholder salience; urgency is the time-sensitivity of the claim, not pressure felt by the stakeholder.
12. Rogers Commission (1986), chapter 5: "The Commission concluded that the Thiokol Management reversed its position and recommended the launch of 51-L, at the urging of Marshall and contrary to the views of its engineers in order to accommodate a major customer."
13. Minto (2009): the pyramid's rules for grouping, mutually exclusive and collectively exhaustive, and the logic tree for breaking a problem into its component questions; Minto developed the method at McKinsey, where it became the consulting profession's standard decomposition discipline.
14. Mill (1843), Book III: the methods of agreement, difference and concomitant variation.
15. Gentner (1983): analogies transfer when relations match, not when surface attributes do.
16. Billah and Scanlan (1991): the textbook resonance account is wrong; the bridge failed through aeroelastic flutter, a self-excited oscillation. Tacoma Narrows collapsed on 7 November 1940, four months after opening.
17. Perrow (1984): interactive complexity plus tight coupling makes cascading failure normal in certain systems.
18. Kahneman and Klein (2009): skilled intuition is trustworthy in high-validity environments with adequate opportunity to learn the cues, and not otherwise.
19. Heuer (1999): the analysis of competing hypotheses; hypotheses are tested by seeking the evidence that disproves them, because a body of evidence is usually consistent with several hypotheses at once, and the analyst's job is to eliminate, not to confirm.
20. Marshall et al. (1988): the prospective double-blind trial, one hundred patients: when the bacterium was cleared, 21 per cent of ulcers relapsed during the twelve-month follow-up, against 84 per cent when it persisted. Rauws and Tytgat (1990) confirmed the pattern: no ulcer relapse in the first twelve months among the seventeen patients cleared of *H. pylori*. The Rauws abstract reports the persistent-infection relapse arm as 17 of 21 with a bracketed 89 per cent; 17 of 21 is 81 per cent, a discrepancy inside the source itself, so no percentage from that arm is used.
21. Warren and Marshall (1983) for the letters announcing the bacterium; Marshall and Warren (1984) for the fuller report; Marshall et al. (1985) for the self-experiment; NIH Consensus Development Panel (1994) for the treatment endorsement; the 2005 Nobel Prize in Physiology or Medicine to Marshall and Warren.

22. Tufte (1997), the Challenger chapter: the count of thirteen charts, the scatter plot reconstruction, and the 26-to-29-degree launch-time forecast he plots against the damage record.
23. Robison et al. (2002): the rebuttal, co-authored by Boisjoly, arguing that the engineers presented the right data for the case they were making and that Tufte's reconstruction misrepresents their work.
24. Martin (2022): the author's own extended discussion of his signature strategy question, what would have to be true, which he calls the most valuable question in strategy.
25. Minto (2009): the pyramid principle itself, the answer first, then the key lines of support, then the detail; the professional-writing version of the bottom-line-up-front discipline.
26. Schweiger, Sandberg and Ragan (1986): dialectical inquiry and devil's advocacy outperformed consensus-seeking on strategic decision quality.
27. Woolley et al. (2010): group performance tracked average social sensitivity and equality of conversational turn-taking, not maximum individual intelligence; later work has debated how strongly the collective-intelligence effect replicates.
28. Klein (1998): the recognition-primed decision research behind the objection in this section.

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Woolley, A. W. et al. (2010). 'Evidence for a collective intelligence factor in the performance of human groups', *Science*, 330(6004), pp. 686-688.

NEWS, COURT RECORDS AND OFFICIAL SOURCES

Martin, R. L. (2022). 'What Would Have to Be True: The Most Valuable Question in Strategy', *Playing to Win/Practitioner Insights*, 22 August. Available at: <https://rogermartin.medium.com/what-would-have-to-be-true-83dac5bd2189>

Report of the Presidential Commission on the Space Shuttle Challenger Accident (1986). Washington, DC: US Government Printing Office. Available at: <https://www.nasa.gov/history/rogersrep/>

Sabra, A. I. (2003). 'Ibn al-Haytham: Brief life of an Arab mathematician', *Harvard Magazine*, September-October. Available at: <https://www.harvardmagazine.com/2003/09/ibn-al-haytham-html>

Deciding What Matters

Notes

1. The test programme is documented in Thompson, G. J., Carder, D. K., Besch, M. C., Thiruvengadam, A., and Kappanna, H. K. (2014), *In-Use Emissions Testing of Light-Duty Diesel Vehicles in the United States* (Morgantown, WV: Center for Alternative Fuels, Engines and Emissions, West Virginia University), prepared for the International Council on Clean Transportation. The \$50,000 cost is reported in Ewing, J., 'How 25 Academic Researchers, \$50,000 and a Pair of Portable Emissions Machines Took Down VW's Image', *The Atlantic*, 25 September 2015 (the \$70,000 sometimes quoted comes from earlier press coverage). The West Virginia team was John German of the ICCT plus researchers Marc Besch, Arvind Thiruvengadam and Hemanth Kappanna. The Jetta's NO_x was 15 to 35 times the US limit depending on driving conditions; the Passat's 5 to 20 times; the BMW X5 met or beat the standard in nearly all conditions.
2. US Environmental Protection Agency, 'EPA, California Notify Volkswagen of Clean Air Act Violations', press release, 18 September 2015. The approximately 11-million figure is from Volkswagen's public statement of 22 September 2015. The €16.2-billion provision is from Volkswagen AG's 2015 annual accounts. Martin Winterkorn was indicted in the United States on 3 May 2018 (unsealed) and charged in Germany in 2019; the German trial was suspended on health grounds on 1 July 2025, according to court statements reported at the time. He has not been tried in either country (checked September 2026). The 2014-2015 sequence in the text, the May 2014 sharing of the results with the EPA, ARB and Volkswagen; the company's response that the excess "could be attributed to various technical issues and unexpected in-use conditions"; the December 2014 voluntary recall of roughly 500,000 vehicles; ARB's laboratory and on-road retesting from May to July 2015 showing limited improvement; the August 2015 refusal of 2016 certificates of conformity; and the 3 September 2015 admission in a technical meeting, is from the California State Senate's Volkswagen defeat-device timeline of 8 March 2016; the Notice of Violation is the joint EPA/CARB announcement of 18 September 2015.
3. Barrett, S. R. H., Speth, R. L., Eastham, S. D., Dedoussi, I. C., Ashok, A., Malina, R., and Keith, D. W. (2015), 'Impact of the Volkswagen emissions control defeat device on US public health', *Environmental Research Letters*, 10(11), 114005 (approximately 59 early US deaths); and Chossière, G. P., Malina, R., Ashok, A., Dedoussi, I. C., Eastham, S. D., Speth, R. L., and Barrett, S. R. H. (2017), 'Public health impacts of excess NO_x emissions from Volkswagen diesel passenger vehicles in Germany', *Environmental Research Letters*, 12(3), 034014 (approximately 1,200 early deaths across Europe, including exports from Germany).

4. Nisbett, R. E., and Wilson, T. D. (1977), 'The halo effect: Evidence for unconscious alteration of judgments', *Journal of Personality and Social Psychology*, 35(4), pp. 250-256. Positive judgments in one domain alter judgments in another, outside awareness.
5. Tversky, A., and Kahneman, D. (1973), 'Availability: A heuristic for judging frequency and probability', *Cognitive Psychology*, 5(2), pp. 207-232.
6. Kahneman, D., and Frederick, S. (2002), 'Representativeness revisited: Attribute substitution in intuitive judgment', in T. Gilovich, D. Griffin, and D. Kahneman (eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment* (Cambridge: Cambridge University Press), pp. 49-81. The Volkswagen sequence above is a reading of the public record cited in notes 1 to 3, organised around their mechanism; the level-by-level questions are reconstructions, not transcripts.
7. Aristotle, *Nicomachean Ethics*, Book III, 1112b ("we deliberate not about ends but about means to ends"); Epictetus, *Handbook* (Enchiridion), section 5 ("What upsets people is not things themselves but their judgments about the things"); Marcus Aurelius, *Meditations*; Confucius, *Analects* 13.3 (the rectification of names); the Buddhist diagnosis draws on the Noble Eightfold Path's first step, right view. Editions in the References.
8. Keeney, R. L. (1992), *Value-Focused Thinking: A Path to Creative Decisionmaking* (Cambridge, MA: Harvard University Press). The Volkswagen framing is this chapter's application of his inversion, not his example.
9. Fischhoff, B. (1991), 'Value elicitation: Is there anything in there?', *American Psychologist*, 46(8), pp. 835-847. Values are partly constructed in the eliciting, not simply retrieved; the method of asking shapes the answer.
10. Goodhart, C. A. E. (1984), *Monetary Theory and Practice: The UK Experience* (London: Macmillan), p. 96. The sentence is his; the better-known 'when a measure becomes a target' phrasing is a later formulation by others, not his words.
11. Fischhoff, B. (1975), 'Hindsight is not equal to foresight: The effect of outcome knowledge on judgment under uncertainty', *Journal of Experimental Psychology: Human Perception and Performance*, 1(3), pp. 288-299. Participants who learned an outcome reliably misremembered their earlier expectations as closer to it.
12. Keeney, R. L., and Raiffa, H. (1976), *Decisions with Multiple Objectives: Preferences and Value Tradeoffs* (New York: John Wiley & Sons). The standard formal treatment of additive value models and their independence conditions; the test in the text is the intuitive version, not the theorem.
13. Kahneman, D., Sibony, O., and Sunstein, C. R. (2021), *Noise: A Flaw in Human Judgment* (London: William Collins). The insurance study: five realistic cases priced independently; the median difference between two underwriters' premiums was 55 per cent, against a median executive guess of 10 per cent, reported in the book's opening chapters and summarised in contemporaneous reviews. The level, pattern and occasion typology is the book's own decomposition of system noise.

14. Tetlock, P., and Gardner, D. (2015), *Superforecasting: The Art and Science of Prediction* (New York: Crown). The practices named: explicit probabilistic forecasts, scorekeeping, updating.
15. The Tylenol account draws on contemporaneous reporting and later case studies: the \$100-million-plus cost as reported by *The New York Times* (29 October 1982); market share falling to about 7 per cent and recovering more than 80 per cent of its pre-crisis share, about 29 per cent of the market, within a year (*Time*, 17 October 1983, which puts the pre-crisis share at about 35 per cent; the often-quoted 37 per cent starting figure comes from Rehak 2002); the recall of about 31 million bottles (Rehak 2002); the resistance Burke faced from the FBI and FDA (*Time*, 17 October 1983); the tamper-resistant packaging roll-out (United Press International, 5 November and 23 December 1982); the *Washington Post's* observation that Johnson & Johnson was never accused of manufacturing or distributing a tainted product (11 October 1982). The Credo text and its 1943 date are from Johnson & Johnson's own archive. This chapter uses the crisis as a judgment case; the public-relations retelling is the version to be wary of.
16. Eisenberger, N. I., Lieberman, M. D., and Williams, K. D. (2003), 'Does rejection hurt? An fMRI study of social exclusion', *Science*, 302(5643), pp. 290-292. Excluded Cyberball players showed increased activity in the dorsal anterior cingulate cortex, a region also associated with the distress of physical pain. Whether the overlap means social and physical pain share a mechanism is debated; the study measured exclusion, not workplace dissent, and the application here is the chapter's.
17. Stasser, G., and Titus, W. (1985), 'Pooling of unshared information in group decision making: Biased information sampling during discussion', *Journal of Personality and Social Psychology*, 48(6), pp. 1467-1478. Groups over-sample shared information; uniquely held facts surface less often, and discussion can worsen decisions.
18. Bikhchandani, S., Hirshleifer, D., and Welch, I. (1992), 'A theory of fads, fashion, custom, and cultural change as informational cascades', *Journal of Political Economy*, 100(5), pp. 992-1026.
19. US House of Representatives, Committee on Transportation and Infrastructure (2020), *Final Committee Report: The Design, Development & Certification of the Boeing 737 MAX* (Washington, DC: US Government Publishing Office). The report's findings include faulty technical assumptions and development flaws in MCAS, Boeing management's lack of transparency toward the FAA, and weak FAA oversight including the delegated certification structure; the abdication framing is the chapter's reading of those findings.
20. Asch, S. E. (1956), 'Studies of independence and conformity: I. A minority of one against a unanimous majority', *Psychological Monographs: General and Applied*, 70(9), pp. 1-70 (123 subjects; mean error rate 36.8 per cent on critical trials; about three quarters conformed at least once); the partner condition, in which a single honest partner cut errors to about a quarter of the unanimous-majority level, is

- reported in Asch, S. E. (1955), 'Opinions and social pressure', *Scientific American*, 193(5), pp. 31-35.
21. Nemeth, C. J., Brown, K., and Rogers, J. (2001), 'Devil's advocate versus authentic dissent: Stimulating quantity and quality', *European Journal of Social Psychology*, 31(6), pp. 707-720, reporting authentic dissent ranked highest and devil's advocate lowest, alongside Schweiger, D. M., Sandberg, W. R., and Ragan, J. W. (1986), 'Group approaches for improving strategic decision making', *Academy of Management Journal*, 29(1), pp. 51-71, on structured dissent methods.
 22. Gigerenzer, G., and Goldstein, D. G. (1996), 'Reasoning the fast and frugal way: Models of bounded rationality', *Psychological Review*, 103(4), pp. 650-669. One-reason decision rules matched or beat multiple regression across a range of real datasets, especially out of sample; the expert-intuition examples and the auditability counterpoint are the chapter's, and the conditions for trusting intuition are Chapter 5's, from Kahneman and Klein (2009).
 23. Simon, H. A. (1956), 'Rational choice and the structure of the environment', *Psychological Review*, 63(2), pp. 129-138. Satisficing is his; the corrupt-proxy application is the chapter's.

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Experience Is Not the Teacher

Notes

1. NASA Mars Climate Orbiter Mishap Investigation Board (1999): the Phase I report's root-cause finding, the failure to use metric units in the coding of the "Small Forces" ground software file used in trajectory modelling. Thruster impulse data were supplied in pound-seconds where newton-seconds were expected; 4.45 is the conversion factor between them. The Board also records that correctly formatted Small Forces files were unavailable until April 1999, so the comparison window was the final five months of cruise, not the whole nine.
2. The \$125 million figure is the orbiter's cost as reported at the time (Witze, 1999); the larger \$327 million figure sometimes quoted covers the whole Mars Surveyor '98 programme, orbiter and lander. Loss-of-signal and entry details follow the Board's account in note 1.
3. Board of Inquiry (1985): the official investigation of the Air Canada Boeing 767 accident at Gimli, Manitoba, 23 July 1983. The fuel-quantity indication system was inoperative, the load was computed manually in pounds against a requirement in kilograms, and the aircraft departed with roughly half the required fuel. There were no fatalities.
4. Weick and Sutcliffe (2007): high-reliability organisations sustain a preoccupation with failure; the decay of reviews into routine is this chapter's application of their argument to the Orbiter record, not a finding from their text. The trajectory-discrepancy reading in this section is likewise the book's interpretation of the Board's account.
5. Cohen and Levinthal (1990): absorptive capacity; recognising, assimilating and applying external knowledge depends on prior related knowledge and outward-facing interfaces. The application to the Orbiter programme is this chapter's hypothetical diagnosis, not the paper's and not a finding from either report.
6. Dunlosky, Rawson, Marsh, Nathan and Willingham (2013): the ten-technique review; practice testing and distributed practice rated highest-utility, re-reading and highlighting and underlining lowest.
7. Squire and Wixted (2011): the cognitive neuroscience of memory since H.M.; hippocampal binding and gradual cortical consolidation over hours to weeks.
8. Walker and Stickgold (2006): sleep as an active phase of memory consolidation; the sleep-deprivation discount on learning is their review's conclusion.
9. Ebbinghaus (1885/1913): the original forgetting measurements; retention drops steeply in the first day or two, then levels off, and each spaced re-learning slows the next decay. The spacing inference is the standard reading of his savings

method.

10. Simon and Chase (1973): the chess reconstruction experiments; masters' advantage holds for game positions and vanishes for random boards, the signature of recognition over recall. Chapter 5 covers the deep-structure side of expert categorisation (Chi and colleagues); this chapter owns the building of the library.
11. Ericsson, Krampe and Tesch-Römer (1993): the original deliberate-practice account, structured activities designed specifically to improve performance, with feedback, at the edge of current ability; the plateau of mere experience is analysed in the same paper.
12. Locke and Latham (2002): thirty-five years of goal-setting research; specific and difficult goals outperform vague "do your best" goals.
13. Hattie and Timperley (2007): feedback among the most powerful influences on learning when it answers three questions: where am I going, how am I going, and where to next.
14. Bjork and Bjork (2011): desirable difficulties, including interleaving, spacing and retrieval practice, slow apparent progress while strengthening durable learning.
15. Kalyuga (2007): the expertise reversal effect; the benefit of instructional guidance reverses as expertise grows, while unguided challenge helps the expert and overloads the novice. Sweller, van Merriënboer and Paas (2019) review the cognitive-load account Chapter 2 introduced; the boundary drawn here is this chapter's application of both.
16. Choudhry, Fletcher and Soumerai (2005): systematic review of sixty-two evaluations; about three quarters reported decreasing performance with years in practice on at least one outcome measure, and about half on all outcomes.
17. Dunning (2011): the Dunning-Kruger effect; the skills needed for competence are those needed to judge it, hence the double curse of the unskilled.
18. Bjork and Bjork (2011): retrieval practice outperforms re-study for durable retention; the same work grounds the familiarity-versus-knowledge distinction in this section.
19. Kolb (1984): the experiential learning cycle, concrete experience, reflective observation, abstract conceptualisation, active experimentation. The three-candidate-explanations discipline in the protocol is this chapter's addition, not Kolb's stages.
20. Argyris and Schön (1978): single-loop versus double-loop learning, correcting errors inside existing assumptions versus questioning the assumptions themselves.
21. Valukas (2010): the bankruptcy examiner's account of Lehman's Repo 105 transactions and risk-management practice. Assets of approximately \$639 billion as of 31 May 2008 come from the bankruptcy filing; the largest filing in US history.
22. Whitehead (1929): the critique of "inert ideas", knowledge received into the mind without being used or tested.

23. Bransford, Brown and Cocking (2000): the National Research Council synthesis of learning science; transfer as the central aim of schooling and training.
24. Sala and Gobet (2017): three meta-analyses of chess, music and working-memory training; far transfer is rare, and effect sizes shrink as study design strengthens.
25. Pashler, McDaniel, Rohrer and Bjork (2008): no adequate evidence for the meshing hypothesis, that matching instruction to preferred learning styles improves outcomes; the multi-form encoding argument in the text is about retrieval routes, not styles.
26. Gentner, Loewenstein and Thompson (2003): analogical encoding; comparing cases side by side yields transferable relational structure.
27. National Audit Office (2017): the NAO identified 6,912 cancelled appointments and estimated the total at over 19,000; the precise figure of 19,494 comes from press coverage of NHS England data and is rounded in the text. The Microsoft security update addressing the exploited vulnerability had been available for two months. The £92 million figure is the Department of Health and Social Care's 2018 estimate of direct costs plus lost output (Department of Health and Social Care, 2018; also reported by Computer Weekly, 2018).
28. Risko and Gilbert (2016): cognitive offloading, using the body and the world to reduce internal cognitive demand. The four test questions in the text are this chapter's protocol built on their account.
29. Macnamara, Hambrick and Oswald (2014): percentages quoted from the article's abstract; the conclusion sentence is quoted verbatim.
30. Ericsson and Harwell (2019): the authors' reply; much of the meta-analysed activity did not meet the original definition of deliberate practice, which requires teacher-designed, individualised training at the edge of ability.

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Whether the Room Will Let You Say It

Notes

1. Lovell and Kluger (1994): the mission account; the explosion came at fifty-five hours fifty-four minutes into the flight, on 13 April 1970, and splashdown on 17 April. Swigert's call is on the flight recordings as "Okay, Houston, we've had a problem here," repeated by Lovell. The carbon dioxide fix fitted the command module's square canisters into the lunar module's round receptacles.
2. Kranz (2000): the Apollo 1 fire, 27 January 1967; the "tough and competent" address to his controllers, tough as forever accountable for what you do or fail to do and competent as never taking anything for granted; and, separately in the same address, his confession that they had been too gung ho about the schedule and had locked out the problems they saw each day in their work.
3. Columbia Accident Investigation Board (2003), volume I, chapter 6: the debris team's imaging dilemma; the cancellation of outside imaging help; and Rocha's unsent email of around 22 January 2003, quoted verbatim, drafted after Paul Shack's 11:45 a.m. message that the Orbiter Project was not requesting outside imaging help. Rocha printed it and shared it with a colleague, later explaining that he did not want to jump the chain of command.
4. Columbia Accident Investigation Board (2003), volume I, chapters 1-3: launch on 16 January 2003; foam separation from the left bipod ramp at 81.7 seconds after launch, striking the left wing's leading edge; breakup on re-entry, 1 February 2003, with the loss of all seven crew.
5. Columbia Accident Investigation Board (2003), volume I: the organisational-causes findings are chapter 7, "The Accident's Organizational Causes"; the "echoes of Challenger" phrase is Board member Sally Ride's observation, quoted in chapter 8, "History as Cause: Columbia and Challenger", whose section 8.1 takes her phrase as its title.
6. Asch (1956): the standard line-judgment studies; conformity on roughly a third of critical trials under unanimous wrong majority pressure, collapsing to a small fraction when one confederate broke unanimity, including when the dissenter gave a different wrong answer, and falling from 36.8 per cent of critical trials to 12.5 per cent when answers were written instead of spoken (Asch 1956, Table 17).
7. Milgram (1963): the remote condition, twenty-six of forty participants (65 per cent) continuing to the maximum shock; with the learner's voice audible, twenty-five of forty (Milgram, 1974). The peer-refusal variation, in which two confederate teachers defied the experimenter and thirty-six of forty participants followed them, is Experiment 17 in the 1974 book; the proximity gradient across variations is documented there.

8. Haslam and Reicher (2012): engaged followership, obedience as enlistment in a cause the participant values. Burger, Girgis and Manning (2011) describe refusal at the direct-order prod, but it came last in Milgram's sequence, so the association does not isolate the wording or establish a causal contrast. The engaged-followership account is a reinterpretation, not proof of a single mechanism. The extension of the identification mechanism to the mission-driven room in this section is this book's, not Haslam and Reicher's finding.
9. Le Texier (2019), drawing on the Stanford archives, and Blum (2018): guard coaching, staged elements, and the revision of the Stanford Prison Experiment's standard telling.
10. Janis (1982): groupthink's symptoms, including illusions of unanimity, self-censorship and direct pressure on dissenters; cohesion as the condition that produces them.
11. Foucault (2001), the 1983 Berkeley lectures as transcribed: parrhesia as "a kind of verbal activity where the speaker has a specific relation to truth through frankness, a certain relationship to his own life through danger"; the friend told he is wrong risks anger, the citizen addressing the tyrant risks more.
12. Kamali (2003): *ikhtilaf*, reasoned disagreement among qualified jurists, as an organised and legitimate feature of Islamic legal method, with coexisting schools of law.
13. Mencius (Lau translation, 1970): the ministerial duty of remonstrance; correction of the ruler as obligation rather than affront. The section frames the ideal official as that tradition's own account.
14. Columbia Accident Investigation Board (2003), volume I, chapter 6, page 156: the debris analysts' position after the team's second meeting, quoted verbatim. The chapter 6 record runs both ways: some managers recognised the seriousness, and some engineering advice ran reassuring on imaging; the failure the board documents is one of escalation and follow-through. The board counts three distinct requests to image Columbia on-orbit; the Debris Assessment Team's first formal meeting on 21 January 2003 ended with its imaging request carried upward, and the requests were declined.
15. Morrison and Milliken (2000): organisational silence as a collective phenomenon, sustained by inference about what speaking costs; the managerial beliefs named in the text are theirs.
16. Columbia Accident Investigation Board (2003), volume I: the independence-compromise finding (chapter 6, submarine-Navy comparison), the dependence finding (chapter 7), and the prescribed attributes (chapters 7 and 9). The centre is the NASA Engineering and Safety Center, announced 15 July 2003, funded through the Chief Safety and Mission Assurance Office (NESC 2004 annual report); the concurrence and formal-dissent mechanisms are NASA's Technical Authority process (NASA Procedural Requirements 7120.5F, chapter 3, carried forward in NASA Interim Directive 7120.148, December 2024).

17. McLean and Elkind (2003): Enron's twice-yearly ranking process and the removal of those at the bottom; Gladwell (2002) describes the same machinery and its talent mythology. "Rank and yank" was the employees' own name for it.
18. McLean and Elkind (2003): Watkins's memo to Kenneth Lay in August 2001 warning of an accounting implosion, and the limited internal review that followed.
19. The reading of Rocha's hedged opening and the room's signals follows the email's text and context in note 3. The catalogue of pressured speech in this section is this book's observation tool, not a checklist from any study.
20. Nemeth (2018): the research programme on authentic dissent; even incorrect minority dissent widens the positions a group examines.
21. Edmondson (1999): the field study of 51 work teams in a manufacturing company; team leader coaching and non-defensive responses to questions and challenges were associated with psychological safety, a correlational finding.
22. Edmondson (1996): the hospital nursing-unit study; the units that reported more errors were those whose people believed honesty would not be punished. Her interpretation is openness rather than worse care; reported rates cannot by themselves distinguish the two.
23. Edmondson and Lei (2014): the review; psychological safety as candour rather than niceness, predicting error reporting, discussion and learning.
24. Vaughan (1996): normalisation of deviance, introduced in Chapter 1 of this book; the Challenger anomaly was O-ring erosion and blow-by. The Columbia parallel as named by Ride is in note 5.
25. Kenny (2019): the costs borne by whistleblowers and the organisation's characteristic response to the act rather than the message; Miceli, Rehg, Near and Ryan (1999) for the federal-employee finding (three waves, 1980-1992) that laws intended to encourage whistle-blowing were accompanied by increased perceived retaliation. The remedial-character reading is this book's inference from that record and Kenny's costs.
26. Edmondson (1999), note 20: the leader's response to questions and challenges as the signal that sets the team's weather. The first-risk formulation is this book's practical reading of that association, not a variable the 51-team study isolated.
27. Frazier, Fainshmidt, Klinger, Pezeshkan and Vracheva (2017): the meta-analysis, 136 independent samples and over 22,000 individuals; the evidence base is largely self-report and cross-sectional, which the objection is entitled to weigh.
28. Edmondson (2018): the safety-accountability matrix, learning, comfort, apathy and anxiety zones, popularised in her later synthesis for practitioners.

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What the Room Does With What It Hears

Notes

1. Bartlit et al. (2011): the management failures behind the blowout, including "ineffective communication and siloing of information", are chapter 5, "Overarching Failures of Management" (the seven-failure list, p. 225); the first explosion at 9:49 p.m. on 20 April 2010 is chapter 4, "Technical Findings", in its accounts of kick detection (p. 181) and the response (p. 197), and the death toll of eleven is the report's own, stated in the foreword and in chapter 4's overview. Chapter 1's reading of the same disaster covered the failures of individual judgment.
2. Darling, Parry and Moore (2005): the Army's Opposing Force, a 2,500-member brigade stationed in the California desert, facing a fresh brigade of more than 4,000 every month, numerically and technologically superior, shown OPFOR's methods in advance, and losing almost always; the authors attribute the standing force's record to its use of the after-action review; the monthly figure of more than 4,000 is the article's own abstract (PubMed 16028819).
3. Edmondson (1999): team learning as an ongoing process of reflection and action, asking questions, seeking feedback, experimenting, reflecting on results, discussing errors.
4. Woolley et al. (2010), pp. 687-688: two studies, 699 people working in groups of two to five (study 1: forty three-person groups; study 2: 152 groups). On the initial factor extraction the first factor accounted for more than 43 per cent of the variance in study 1 and 44 per cent in study 2 (31 and 35 per cent after principal-axis extraction); the next factors accounted for only 18 and 20 per cent.
5. Woolley et al. (2010): *c* was not strongly correlated with the average or maximum individual intelligence of members; the significant correlates were average social sensitivity, equality of conversational turn-taking, and the proportion of women, the last largely mediated by social sensitivity (Sobel $z = 1.93$, $P = 0.03$); group satisfaction, cohesion and motivation were not significantly correlated with *c*.
6. Credé and Howardson (2017), pp. 1483-1492: a re-examination of the data from six previously published samples used to examine the collective-intelligence factor, concluding that the evidence for a general *c* was weaker than its reception suggested; Bates and Gupta's three-study counter is described in Section 9 and pinned in its own note.
7. Project Aristotle, 180 teams studied over two years, psychological safety the strongest of the dynamics identified: Google's own account is its re:Work guide 'Understand team effectiveness', internal people-analytics work that has not been independently peer-reviewed; Duhigg (2016) is the narrative account. What that

safety costs and buys was Chapter 8's ground.

8. Wegner (1987): transactive memory, a group's combined system for encoding, storing and retrieving knowledge through a shared index of who knows what; the three component processes in the text, directory updating, information allocation and retrieval coordination, are from Wegner (1995).
9. Lewis (2004): sixty-four MBA consulting teams, 261 members, followed through a full project; transactive memory systems emerged in the planning phase from initial conditions, distributed expertise and member familiarity, and developed with the nature and frequency of communication; frequent face-to-face communication built them while communication by other means had no effect, and more developed systems were positively related to team performance and viability, an associational finding in student teams, not a causal one in intact organisations; the face-to-face association is that sample's result, not a general rule about channels.
10. US Army (2013): the leader's guide to after-action reviews; the guide's own sentence is "The AAR is not a critique. No one, regardless of rank, position, or strength of personality, has all of the information or answers"; the critique, one viewpoint focused only on what is wrong, "prevents candid and open discussion of training events and stifles learning and team building".
11. US Army (2013): the four questions in sequence, what was supposed to happen, what actually happened, why, and what to sustain and improve, with events reconstructed before causes are argued.
12. US Army (2013): the ground rules, participation across ranks, and the facilitator's role in keeping the review off individuals; the guide separates formal reviews, planned and resourced weeks ahead, from informal ones run on the spot with the same questions and rules. The guide's reviews examine soldier, leader and unit performance against task standards; the appraisal safeguard in this section is this book's proposed organisational rule, not an Army ground rule and not a promise a facilitator can make on an employer's behalf.
13. Darling, Parry and Moore (2005): OPFOR's reviews feeding raw material back into the execution cycle, and the standard that a lesson is not considered learned until it is successfully applied and validated.
14. Szulanski (1996) frames the across-space half: knowledge generated in one part of a firm stays invisible to parallel units facing the same problem.
15. McKinsey Global Institute (2012): the average interaction worker spends an estimated 28 per cent of the workweek managing email and nearly 20 per cent looking for internal information or tracking down colleagues who can help with specific tasks.
16. Szulanski (1996): internal stickiness, the difficulty of transferring best practice within a firm even with intent; the sample is 271 observations spanning 122 transfers of 38 practices in eight companies; the barriers he measured are knowledge barriers, causal ambiguity about why the practice works, the

recipient's absorptive capacity, and an arduous relationship between source and recipient.

17. Polanyi (1966): tacit knowing, 'we can know more than we can tell'; the explicit layer of a practice travels in documents, the tacit layer does not.
18. NASA (n.d.): the agency's Pause and Learn, the Army's after-action review adapted so that sessions run throughout a project's life cycle rather than at its end, capturing the knowledge gained and sharing it across the organisation.
19. National Aeronautics and Space Administration: the five-stage process, collecting, assessing, validating, documenting and infusing lessons, discoverable and searchable to the broadest extent possible, is NPR 7120.6, chapter 1, now obsolete and no longer used; the current NPD 7120.6A, 'Knowledge Policy for Programs and Projects' (effective 16 December 2019, change 1 of 10 July 2024, expiring 10 July 2029), cancels it and directs instead that the agency's technical and programme knowledge be captured and accessible across all centres and mission directorates, promoting capture, retention, utilisation and sharing as leading practices, with the Lessons Learned Information System one component of a wider knowledge-sharing system.
20. Collison and Parcell (2004): BP's Retrospect, the structured end-of-project capture, and the peer assist that carries lessons to the next team before it starts; the learn-before, learn-during, learn-after rhythm is theirs.
21. Huddleston et al. (2014): the Mayo Clinic care review process, every death reviewed systematically, explicitly non-punitive, aimed at organisational learning.
22. Cullinan et al. (2023): the evolved process, weekly huddles for early closure of straightforward cases, a multidisciplinary committee, a standardised taxonomy, and its transfer to Sheikh Shakhboub Medical City; a baseline quarter at 78.3 per cent of reviews completed within forty-five days against a 95 per cent target, rising to a sustained 100 per cent after a twelve-week virtual implementation.
23. Dalio (2017): the issues log, radical transparency about error, and the conversion of mistakes into written principles; the stated rule that it is acceptable to make mistakes and unacceptable not to learn from them.
24. Dalio, interviewed by Henry Blodget (2017): "Twenty percent of our people in the first year don't like our culture and leave. Another 10% don't work out. So in the first two years, 30% of the population goes, and then 70% stays. From that point forward, we have hardly any loss." His definition of radical truth in the same interview: putting on the table, together, the things people ordinarily hide, particularly mistakes, problems and weaknesses.
25. Weick and Sutcliffe (2015): the high-reliability-organisation tradition; the three elements of mindfulness named in the text, preoccupation with failure, reluctance to simplify and sensitivity to operations, are the account's own terms.
26. National Commission on Terrorist Attacks (2004): the March 2000 cable recording Hazmi's flight to Los Angeles, with the CIA aware of Mihdhar's US visa but not

then of his entry, is chapter 6 (pp. 181-182); the immigration service's establishment of Mihdhar's January 2000 entry on 22 August 2001 and the TIPOFF watch-listing of both men on 24 August 2001 are chapter 8 (pp. 267-270); the July 2001 Phoenix memo and the August 2001 Moussaoui case are chapter 8 (pp. 272-275); the memo's recommendations were not acted on and no manager at headquarters saw it before 11 September; Moussaoui had little knowledge of flying, wanted Boeing 747 simulator training as "an ego boosting thing" and to learn to "take off and land" a 747, a Minneapolis agent suspected he might be planning to hijack a plane, and headquarters believed there was insufficient probable cause for a search; "the system was blinking red" is Tenet's phrase and chapter 8's title.

27. National Commission on Terrorist Attacks (2004), chapter 3, 'Legal Constraints on the FBI and "the Wall"' (pp. 79-80): the July 1995 procedures required sharing but regulated its manner and were 'almost immediately misunderstood and misapplied', with far less shared in practice than they allowed; the Office of Intelligence Policy and Review assumed a gatekeeper role the procedures never gave it; agents came to believe, incorrectly, that no FISA information could be shared with criminal investigators, a belief that spread to intelligence information generally; and FBI leadership warned that too much sharing could be 'a career stopper'.
28. National Commission on Terrorist Attacks (2004), pp. 416-419: the need-to-know system's assumption that the risk of disclosure outweighs the benefits of wider sharing, with sanctions for sharing and no punishments for not sharing; the recommendation that information procedures provide incentives for sharing, 'to restore a better balance between security and shared knowledge'; reports beginning with the data in their most shareable form, separated from sources and methods; further access by query under the network's rules, with an audit trail; discoverability of clues by experts at the edge; horizontal sharing across agency lines in a 'trusted information network'. The commission made no claim that the redesign would have prevented the attacks.
29. Chapter 8's four voice actions: ask for the disagreement, say the confidence level, find one ally, open a second channel.
30. Riedl et al. (2021): meta-analytic factor analysis across twenty-two studies, 5,279 individuals in 1,356 groups; strong support for a general collective-intelligence factor, most strongly predicted by group collaboration process, ahead of individual skill and group composition.
31. Bates and Gupta (2017): three studies, 312 people; individual IQ accounted for around 80 per cent of group-IQ differences, with turn-taking and number of women unsupported as predictors, and a structural model in which social perceptiveness exerted no influence on the group factor (the published abstract, doi:10.1016/j.intell.2016.11.004).

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Building Critical Thinking Habits

Notes

1. Nadella (2017): the account of Microsoft's culture, the shift from know-it-alls to learn-it-alls, and the growth-mindset framing are the chief executive's own telling; they are used here as his account, not as independent measurement.
2. Rock (2018): the 2016 compression of Microsoft's leadership principles into six words, create clarity, generate energy, deliver success, and the reasoning that long attribute lists fail under pressure; the author led the consulting partner in the programme, so this is the partner's account of its own work.
3. Wood and R nger (2016): the cortico-striatal basis of habit formation, the cue-routine-reward loop, and the shift of dopamine signalling from reward to predictive cue, reviewed across the behavioural and neuroimaging literature.
4. Grillner, Robertson and Stephenson-Jones (2013): the basal ganglia as an ancient, evolutionarily conserved action-selection circuit.
5. Lally, van Jaarsveld, Potts and Wardle (2010): 96 participants recruited, 82 supplying sufficient data, 62 yielding fitted curves; the 66 days is a modelled median to 95 per cent of the automaticity asymptote among the 39 well-fitting participants, with a modelled range from 18 to 254 days; missing a single opportunity did not materially affect the process.
6. Judah, Gardner and Auger (2013): habit formation for flossing, with context stability predicting the speed of automaticity.
7. Gollwitzer (1999): implementation intentions, if-then plans linking a situational cue to a response, and their strong effects on follow-through.
8. Gollwitzer and Sheeran (2006): the meta-analysis across ninety-four tests, reporting a medium-to-large effect ($d = .65$) of implementation intentions on goal achievement.
9. Clear (2018): habit stacking, anchoring a new routine to an established one; a popular synthesis, labelled as such.
10. Aristotle, Nicomachean Ethics, book 2: excellence as habituation, "we become just by doing just acts"; the Ross translation.
11. Tang, H lzel and Posner (2015): the neuroscience of mindfulness meditation, attention and self-regulation mechanisms, with the field's methodological cautions.
12. Goldberg et al. (2018): mindfulness-based interventions for psychiatric conditions, a meta-analysis finding effects comparable to other active treatments.

13. Irvine (2009): the Stoic daily practices, including the evening review, in a modern reconstruction.
14. Robertson (2019): Stoic practice as daily training, a modern account.
15. Wegner (1994): ironic processes of mental control; attempted suppression monitors for the suppressed thought and thereby sustains it.
16. Duhigg (2012): the cue-routine-reward loop and the golden rule of habit change, keep the cue and the reward and change the routine; a popular synthesis, used here as such.
17. Bouton (2004): extinction as new learning that leaves the original association intact, with the extinguished behaviour renewable by a change of context.
18. Arnsten (2009): stress signalling impairs prefrontal cortex structure and function, weakening deliberate control under pressure.
19. Kabat-Zinn (1994): mindfulness as non-judgmental observation of one's own mental events.
20. Berner and Graber (2008): overconfidence as a cause of diagnostic error in medicine, with debiasing strategies centred on deliberately re-opening first conclusions.

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Integrated Decision Architecture

Notes

1. NTSB (2010), AAR-10/03: the cockpit voice recorder timeline (birds at 15:27:10; "my aircraft" at 15:27:23; the mayday call at 15:27:33; "we're unable, we may end up in the Hudson" at 15:28:05; "we're gonna brace" at 15:30:43), the bird encounter at 2,818 feet about 4.5 miles north-northwest of runway 22, the 214-knot maximum against the 300-knot relight optimum, and the ditching. The 213 seconds is the recorder span itself, 15:27:10 to 15:30:43, used as the text says: an approximation, not a measurement to the second.
2. NTSB (2010), citing US Airways records: the captain's 19,663 total flight hours, including 4,765 in the A320; he had learned to fly as a teenager.
3. NTSB (2010), citing US Airways records: the first officer's 15,643 total flight hours, 37 of them in the A320.
4. Sullenberger's own account of his first reaction as disbelief, from his memoir and interviews; personal testimony, used as such.
5. NTSB (2010): the cockpit voice and flight data record for the accident sequence, the takeover ('my aircraft', 15:27:23), the mayday call (15:27:33), the dual-failure checklist with the 214-knot maximum against the 300-knot relight optimum, and the 'we may end up in the Hudson' call (15:28:05).
6. NTSB (2010), section 1.16.3: twenty engineering-simulator runs at the return scenario, five discarded; eight of the remaining fifteen (53 per cent) landed successfully when the turn was immediate, two of six to runway 22 at LaGuardia, five of seven to runway 13, one of two to runway 19 at Teterboro.
7. NTSB (2010), section 1.16.3: a single further run to runway 13 with a 35-second delay, the agency's allowance for the time a real crew needs to recognise the extent of the thrust loss and decide on a course of action, was unsuccessful. The text reports the single delayed run as exactly that.
8. Rivera, Talone, Boesser, Jentsch and Yeh (2014): startle and surprise on the flight deck, documented largely through voluntary incident reports; used here for the general demand such events place on a crew, not for this crew's state.
9. Kahneman (2011) and Kahneman and Tversky (1974): the dual-process framework introduced in Chapter 2, System 1 fast and patterned, System 2 slow and deliberate.
10. The reading of the cockpit record through recognition-primed decision-making is this chapter's inference, labelled as such in the text; the record itself shows the calls and the times, not the cognition.

11. Dane and Pratt (2007): intuition in managerial decision-making as affectively charged judgment from rapid, nonconscious pattern recognition, contingent on domain experience.
12. Weick and Sutcliffe (2007): the reluctance to simplify as a hallmark of high-reliability organising.
13. Spiro, Coulson, Feltovich and Anderson (1988): cognitive flexibility theory, restructuring as the mark of advanced knowledge in ill-structured domains.
14. Klein (1989, 1998): the recognition-primed decision model and its five moves, with experts typically generating a single workable option rather than comparing sets.
15. Simon and Chase (1973): the estimate of roughly 50,000 chunks in the master's pattern library, from the chess research.
16. Simon (1987): "Intuition and judgment, at least good judgment, are simply analyses frozen into habit and into the capacity for rapid response through recognition", from his Academy of Management Executive paper on intuition and emotion in management decisions.
17. Bruckmaier, Krauss, Binder, Hilbert and Brunner (2021): cognitive illusions persisting even in those who know them, and who can solve which.
18. Kahneman and Klein (2009): the reconciliation, intuition trustworthy given a high-validity environment and adequate feedback, with the physicians and investors of the text as their low-validity territory.
19. Nisbett, Peng, Choi and Norenzayan (2001): analytic versus holistic systems of thought; used here at the modest scope the text states.
20. Ericsson, Krampe and Tesch-Römer (1993): deliberate practice defined by targeted goals, full attention, immediate feedback and adjustment; and Ericsson's repeated objection to the 10,000-hour rule as a corruption of the finding.
21. Macnamara, Hambrick and Oswald (2014): deliberate practice explaining 26 per cent of performance variance in games, 21 per cent in music, 18 per cent in sport, 4 per cent in education and under 1 per cent in the professions.
22. Dreyfus and Dreyfus (1986): the five-stage model of skill acquisition; Benner (2004): its application in nursing. The four-rung conscious-competence ladder in Table 11.1 is a folk teaching model, as the text says, used for teachability, not attributed to this research.
23. Miller (1956): the classic seven plus or minus two pricing of working memory; Cowan (2001): the revision down to about four chunks, both as Chapter 2 discussed.
24. Klein (1998): expert filtering, the discarding of irrelevant cues at speed, as the core of fireground expertise; the lieutenant's case is the book's opening interview, the too-hot, too-quiet cues as the published account gives them.
25. Lilienfeld, Ammirati and Landfield (2009): the debiasing literature's sober scope, bias made visible and correctable rather than erased.

26. Mectizan Donation Program, 'History of the Program' (mectizan.org); Coyne and Berk's World Bank history of the programme (2002, document 31570); the New York Times report of 22 October 1987, p. A14: ivermectin's veterinary origin, the WHO field trials of 1982-85, the 18 million then afflicted, the failed commercial route at about three dollars a dose and the failed search for third-party payers at one dollar, the donation decision that followed, Vagelos's announcement 'as much as needed, for as long as needed', the reported inattention to the donation's financial implications at the decision point, the partnership with the WHO, the World Bank and the Task Force for Global Health, and the programme's current reach across onchocerciasis and lymphatic filariasis. The reading of the decision through this chapter's lens-collision structure is the chapter's, not the sources'.
27. Dunning and Kruger (1999): overconfidence at its peak precisely where competence is absent; the text applies it to novel situations, where the pattern library is empty.
28. Kahneman and Klein (2009): the two conditions of Section 5 restated as the web's operating boundary; the laundered-feedback phrasing is this chapter's.
29. Endsley, Bolté and Jones (2003): naturalistic decision-making under constraint; the conditions the toolkit is reshaped for.
30. Schön (1983): the reflective practitioner; structured reflection on one's own decisions as the engine of professional learning.

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Group Judgment and Failure Prevention

Notes

1. Rogers Commission (1986), vol. 1, ch. 5 and chronology: the narrated conference is the evening's second teleconference, which began at 8.45 p.m. EST; the off-net caucus ran from about 10.30 p.m. and the conference resumed at approximately 11 p.m. McDonald testified the weatherman was "projecting temperatures as low as 18 degrees Fahrenheit some time in the early morning hours of the 28th". 18°F was the forecast overnight low, not a launch temperature; ambient at launch was 36°F (note 8).
2. Rogers Commission (1986), vol. 1, ch. 5: in July 1985, after STS 51-B showed erosion of a secondary O-ring, "a launch constraint was placed on flight 51-F and subsequent launches. These constraints had been imposed and regularly waived by the Solid Rocket Booster Project Manager at Marshall, Lawrence B. Mulloy"; there were "six consecutive waivers prior to 51-L", and neither the constraint nor the waivers were known to Level I (Moore) or Level II (Aldrich).
3. Rogers Commission (1986), vol. 1, ch. 5: Boisjoly – "we should not fly outside of our data base, which was 53 degrees"; the second teleconference charts recorded that "the worst blow-by occurred on SRM 15 (STS 51-C) in January 1985 with O-ring temperatures of 53 degrees Fahrenheit". The 53 degrees was Thiokol's calculated O-ring temperature for 51-C, not an ambient temperature.
4. Rogers Commission (1986), vol. 1, ch. 5: Boisjoly testified that SRM-22 (flight 61-A, October 1985) showed soot blow-by on a launch at 75 degrees; after the caucus, Thiokol's own statement to the net was that "the temperature effects were a concern, but that the data were admittedly inconclusive".
5. Rogers Commission (1986), vol. 1, ch. 5: "My God, Thiokol, when do you want me to launch, next April?" Mulloy testified the quotes "derive from a single thought that may have been expressed by me using some of those words", disputing the context; McDonald separately recalled "You guys are generating new Launch Commit Criteria."
6. Rogers Commission (1986), vol. 1, ch. 5: Boisjoly – "Mr. Mason said we have to make a management decision. He turned to Bob Lund and asked him to take off his engineering hat and put on his management hat." Lund confirmed the instruction in his own testimony of 25 February 1986.
7. Rogers Commission (1986), vol. 1, ch. 5: Boisjoly – "There was never one comment in favor, as I have said, of launching by any engineer or other nonmanagement person in the room before or after the caucus."
8. Rogers Commission (1986), vol. 1: launch at 11.38 a.m. Eastern, ambient temperature 36°F, the coldest shuttle launch to that date; vehicle breakup 73 seconds into

flight; seven crew lost, including Christa McAuliffe, selected under the Space Flight Participant Program to become the first teacher in space; she never reached space.

9. CAIB (2003), vol. 1, ch. 2: at 81.7 seconds after launch, at about 65,600 feet, a large piece of insulating foam came off the External Tank where the orbiter attaches and struck the left wing's leading edge at 81.9 seconds; the strike "was not detected by the crew on board or seen by ground support teams until the next day, during detailed reviews of all launch camera photography and videos".
10. CAIB (2003), vol. 1, pp. 156-157: Debris Assessment Team members, asked what "mandatory need" meant, "replied with a shrug of their shoulders"; the board described their position as "wanting images to more accurately assess damage while simultaneously needing to prove to Program managers, as a result of their assessment, that there was a need for images in the first place".
11. CAIB (2003), vol. 1, pp. 156-157: Rocha's unsent email is quoted verbatim from the report. "When asked why he did not send this e-mail, Rocha replied that he did not want to jump the chain of command." He printed the draft and shared it with a colleague.
12. Vaughan (1996), *The Challenger Launch Decision*: the concept and the term normalisation of deviance (her term in the original spelling is "normalization").
13. Vaughan (1996): the five-step loop is this book's teaching compression of Vaughan's account, not her numbering.
14. Rogers Commission (1986), vol. 1, ch. 5: the July 1985 constraint and six consecutive waivers, restated here as the record's own instance of the loop; the waivers never reached Levels I or II.
15. Vaughan (1996): past survival read as proof of safety; the attention machinery that makes the absence salient is Chapter 2's and Chapter 3's.
16. Starbuck and Milliken (1988), 'Challenger: Fine-tuning the odds until something breaks'; the sunk cost parallel is Chapter 3's (Arkes and Blumer 1985; see Chapter 3's references).
17. Harvey (1974): the parable as published – the family is at home on a back porch in Coleman, Texas, on a July afternoon, and drives fifty-three miles to Abilene; nobody wanted to go.
18. Janis (1972), *Victims of Groupthink*; Harvey (1974) explicitly frames his puzzle as the management of agreement, distinct from the management of conflict.
19. Kahneman and Tversky (1979): the asymmetric pricing of an immediate, certain, personal cost against a delayed, uncertain, shared one is this book's application of prospect theory to the silence decision.
20. Rogers Commission (1986), vol. 1, ch. 5: Lund's testimony – he did not realise, "until after that meeting and after several days", how completely the company's position had changed.

21. The System 1/System 2 vocabulary is Chapter 1's; "System 1 at scale" is this book's reading, not a term from the literature.
22. Esser (1998): review of twenty-five years of groupthink research; per the published abstract, the empirical literature was small but growing, many theoretical propositions remained untested, and the framework's value was judged largely heuristic. It is supportive context for the conformity pressure, not a direct test of Harvey's Abilene mechanism.
23. Harvey (1974); Edmondson (2018).
24. Milliken, Morrison and Hewlin (2003): thirty-four of the forty professionals interviewed (85 per cent) reported at least one occasion of feeling unable to raise an important issue or concern with their supervisors – a self-report interview finding, not a population rate of all professionals.
25. Detert and Edmondson (2007): the futility logic – speaking up is pointless because nothing will change – as a documented driver of silence.
26. Edmondson (2018); Kish-Gephart, Detert, Trevino and Edmondson (2009) on the conditions that silence employee voice.
27. Edmondson (2012, 2018): the impression-management calculus; the cost table is this book's framing.
28. Eisenberger, Lieberman and Williams (2003): the original Cyberball fMRI study – social exclusion during a ball-toss game activated the dorsal anterior cingulate cortex, which the authors associated with the distress of physical pain. The study did not examine anticipated workplace exclusion or voice decisions, and a later meta-analysis of the Cyberball literature (Mwilambwe-Tshilobo and Spreng, 2021) found exclusion reliably engages the default network rather than the dACC. The workplace link in the text is the book's possible analogy, not the study's finding.
29. The five operations are Chapter 2's: attention, working memory, analysis, metacognition, extension. The claim in this section is deliberately narrower than a machinery failure: the operations visibly engaged complete their run, and what is blocked is the organisational translation of their product into voice. Chapter 2's extension, the analogical transfer of structure into new domains, is a different operation from speaking up; the text does not claim it fired, and the diagnosis does not depend on it.
30. Asch (1956), 'Studies of independence and conformity: A minority of one against a unanimous majority'.
31. Asch (1956): conformity on roughly a third of critical trials; about three-quarters of participants conformed at least once; post-experiment interviews documented self-doubt and the wish to avoid standing out.
32. Haslam and Reicher (2012): engaged followership, obedience as enlistment in a valued cause. The bare-order refusal finding is Burger, Girgis and Manning's (2011) analysis of the session records. The peer-refusal variation is Experiment 17 in Milgram (1974): thirty-six of forty participants defied. The Stanford revision: Le

Texier (2019), drawing on the Stanford archives, and Blum (2018).

33. The informational/normative distinction is the standard reading of the conformity literature built on Asch (1956); Moscovici (1985) is the companion account of how a consistent minority can influence a majority.
34. Sherif (1936): the autokinetic experiments – individual judgment anchored on the group's estimate under genuine ambiguity.
35. Sunstein (2002): group polarisation (his article title uses the US spelling); the risky-shift link and the Chapter 3 anchoring parallel are this book's.
36. Edmondson (2018); Weick and Sutcliffe (2001).
37. Weick, Sutcliffe and Obstfeld (1999); Weick and Sutcliffe (2001): the high-reliability research programme; La Porte (1996) for the demanding, at-risk character of such organisations.
38. Rochlin, La Porte and Roberts (1987): the carrier flight-operations study that founded the tradition.
39. Weick and Sutcliffe (2001): the five characteristics; the pathology-mapping column of Table 12.2 is this book's.
40. Weick and Sutcliffe (2001): deference to expertise – decision authority migrates to the person with the relevant knowledge, whatever their rank.
41. Westrum (2004), 'A typology of organisational cultures': pathological, bureaucratic and generative cultures; Table 12.3 condenses his descriptors.
42. The PRISM mapping of Westrum's typology is this book's reading; the sequence itself is Chapter 1's.
43. "System 2 institutionalised" is this book's framing; the characteristics are Weick and Sutcliffe's (2001).
44. Rogers Commission (1986); Vaughan (1996): the investigation and the decade-long sociological analysis that make this the reference case; Hall (2003) for the comparative organisational-failure argument across the two accidents.
45. Rogers Commission (1986), vol. 1, ch. 5: the July 1985 constraint, six consecutive waivers, unknown to Levels I and II (note 2).
46. Rogers Commission (1986), vol. 1, ch. 5: Lund's testimony on not realising until days later how far the position had moved (note 20).
47. Rogers Commission (1986), vol. 1, ch. 5: Boisjoly's testimony; the engineers were not asked to vote in the caucus (note 7).
48. Rogers Commission (1986), vol. 1, ch. 5: the hats instruction; Chairman Rogers asked Lund how he explained changing his mind when he changed his hat (note 6).
49. CAIB (2003), vol. 1, ch. 8, 'History as Cause: Columbia and Challenger', whose opening section is titled 'Echoes of Challenger'.

50. CAIB (2003), vol. 1, ch. 6.1, 'A History of Foam Anomalies': foam debris reclassified "in-family" and treated as an "accepted risk"; bipod-ramp foam losses were "some of the largest pieces of debris that have struck the Orbiter". On the leading edge: RCC panels were impact-tested with ice and metal projectiles (ch. 3.3), not with foam.
51. CAIB (2003), vol. 1, pp. 156-157: Rocha's unsent email and his reason (note 11).
52. CAIB (2003), vol. 1, ch. 7: "In the Board's view, NASA's organizational culture and structure had as much to do with this accident as the External Tank foam"; the traits quoted are from the board's organisational-causes statement, including "reliance on past success as a substitute for sound engineering practices" and "organizational barriers which prevented effective communication of critical safety information and stifled professional differences of opinion".
53. CAIB (2003), vol. 1, ch. 7 and ch. 11: the recommended independent technical authority and safety organisation with line authority; the assessment that this fix was not made is this book's summary of the later record.
54. House Committee on Transportation and Infrastructure (2020): the final committee report on the 737 MAX after a two-year investigation; 346 deaths across Lion Air Flight 610 (October 2018) and Ethiopian Airlines Flight 302 (March 2019).
55. House Committee (2020); Herkert, Borenstein and Miller (2020): MCAS's reliance on a single angle-of-attack sensor, and the design pressure behind it.
56. House report: the human-computer-interaction failure – MCAS issued repeated nose-down trim commands on faulty single-sensor data, countering the crews' inputs, with no transparent feedback to the crew; MCAS's absence from the flight crew manual and training left the pilots fighting a system they did not know was there.
57. House Committee (2020): the summary language quoted – "faulty technical assumptions by Boeing's engineers, a lack of transparency on the part of Boeing's management, and grossly insufficient oversight by the FAA".
58. Boeing internal messages released to Congress and the FAA in 2019-2020 and reproduced in the investigation record: the chief technical pilot's November 2016 message that MCAS was "running rampant" in the simulator, and the separate exchange describing the aircraft as "designed by clowns who in turn are supervised by monkeys". Former test pilots later disputed whether the "running rampant" exchange showed an actual MCAS design problem or simulator software problems (Reuters); the messages evidence concern inside the company, not that it reached decision-makers. The House report documents the broader MCAS disclosure and training gap (what the FAA, customers and pilots were and were not told); it does not trace these specific messages.
59. In re The Boeing Company Derivative Litigation, Delaware Court of Chancery (2021): the court found the plaintiffs' claims could proceed, noting the board had no committee specifically responsible for airplane safety, that safety monitoring was passive, and that management's safety reporting to the board was sporadic and ad

hoc.

60. The US Department of Justice record: deferred prosecution agreement (January 2021); breach determination (May 2024); Boeing's agreement to plead guilty to the fraud conspiracy charge (July 2024); Judge Reed O'Connor's rejection of that plea deal (December 2024); the non-prosecution agreement reached in 2025 and the judge's approval of dismissal (November 2025); upheld by a federal appeals court (March 2026). Sources: DOJ filings; Reuters (16 May 2025; 6 November 2025; 31 March 2026).
61. FAA audit as reported by the New York Times (11 March 2024): of 89 product audits of Boeing's 737 MAX production, conducted after the January 2024 Alaska Airlines door-plug blowout, Boeing failed 33, with 97 instances of alleged noncompliance documented. The same note carries the FAA Section 103 Expert Panel report (26 February 2024), which found Boeing's safety culture implementation inadequate and confusing, with a disconnect between senior management and the workforce (FAA expert panel final report; Reuters, 26 February 2024).
62. Chapter 1 carries the Williams narrative and the night of 20 April 2010; this section deliberately reuses its frame.
63. CSB (2016), Investigation Report, vol. 3 (Macondo well): the human-factors and organisational findings behind the barrier failures. (The findings used here are vol. 3's; vol. 4 covers regulatory oversight.)
64. CSB Investigation Report vol. 3, ch. 1 ('Phase 3 – Evidence of Confirmation Bias'): the negative-pressure-test chronology – kill line bled to zero with thirty minutes of no flow while drillpipe pressure held at about 1,400 psi; discussions ran about an hour and a half; the night toolpusher's 'bladder effect' (annular compression) explanation, which post-incident analysis could not support; the record disputes whether the whole crew accepted the rationale, but displacement proceeded; a well site leader described the test as 'squirrely' to the onshore drilling engineer and then reported no problems.
65. Chapter 1's locked account: four BP and Transocean managers aboard on a "management visibility tour"; the rig had not had a single lost-time incident in seven years.
66. CSB (2016), vol. 3: concerns not escalated; schedule and cost pressure; silence about process safety normalised.
67. CSB (2016), vol. 3: the organisational-causes list quoted in the text.
68. CSB (2016); Weick and Sutcliffe (2001): the general conditions named are this book's synthesis.
69. The five protocols are this book's curation; each component's evidence is cited in the notes below; the package as a whole has not been validated as a bundle.
70. Klein (2003): the pre-mortem as a remedy for overconfidence and suppressed doubt; Kahneman (2011) endorses it on the same grounds.
71. Klein (2003); Kahneman (2011): why the reframing works.

72. Mitchell, Russo and Pennington (1989): explaining an outcome with certainty produced more candidate explanations than forecasting it as a possibility; the study's own analysis attributed the effect to outcome certainty, with temporal perspective having little influence. The study therefore supports the pre-mortem's 'assume it has failed' framing via certainty, not via imagining the future as the past.
73. The NASA pre-mortem counterfactual is this book's, labelled in the text; it illustrates the mechanism and claims nothing about a rewritten past (Vaughan 1996 for the underlying record).
74. Klein (2003); Edmondson (2018): red teaming and institutionalised dissent.
75. Klein (2003): the blue-team/red-team variant in military planning and intelligence analysis.
76. Paulus and Brown (2007); Edmondson (2018): silent brainstorming and the Highest Paid Person's Opinion.
77. Paulus and Brown (2007): simultaneous silent writing as the mechanism that removes anchoring.
78. Diehl and Stroebe (1987); Paulus and Brown (2007): production blocking, evaluation apprehension and social loafing in interactive groups.
79. Weick and Sutcliffe (2001); Edmondson (2018): stop-work authority as an HRO feature.
80. Duhigg (2012): O'Neill's Alcoa safety campaign, including giving workers his own phone number with the instruction to call him directly about unaddressed safety risks; the injury-rate and profit record is as Duhigg reports it.
81. Weick and Sutcliffe (2001); Edmondson (2018): near-miss reporting under genuine stop-work authority.
82. Edmondson (2018); Weick and Sutcliffe (2001): the leader as architect of the conditions for collective intelligence; "architect of intelligence" is this book's label for the pattern.
83. Duhigg (2012), *The Power of Habit*: Paul O'Neill's tenure at Alcoa – the lost workday injury rate fell from 1.86 per 100 workers to 0.2, and annual net income at his retirement was five times higher than when he started. A journalist's published account of the company figures, cited as such. This note wires the previously orphaned Duhigg reference.
84. Edmondson (2018): the leader's response to bad news as the teaching moment.
85. Edmondson (2012, 2018): the definition of psychological safety; Kahn (1990) supplied the founding account of the psychological conditions of engagement. Chapter 8, 'Whether the Room Will Let You Say It', carries the full evidence base and the building behaviours; this section adds only the infrastructure argument. *Right Kind of Wrong* (2023) is the current statement of Edmondson's framework, extending psychological safety into the science of failing well.

86. Edmondson (2018); Weick and Sutcliffe (2001): the consequences of high and low psychological safety.
87. NPR (Howard Berkes): the interview of 28 January 2016, '30 Years After Explosion, Challenger Engineer Still Blames Himself'; the follow-up of 25 February 2016, 'Your Letters Helped Challenger Shuttle Engineer Shed 30 Years Of Guilt', which carries the family's account of the peace the letters gave him; and the report of his death, 21 March 2016, 'Challenger Engineer Who Warned Of Shuttle Disaster Dies'.

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Ethics, Cultural Intelligence, and Moral Reasoning in Critical Thinking

Notes

1. On the Hmong exodus and the CIA covert war in Laos: Fadiman (1997); the Los Angeles Times obituary (2012) records that about 150,000 Hmong fled Laos after Saigon fell in 1975, and Brown (2009) records the CIA recruitment and the resettlement in California's Central Valley.
2. Los Angeles Times (2012): Lia was "the first American-born daughter"; her twelve older siblings were born in Laos and one further sibling in a refugee camp in Thailand.
3. Fadiman (1997): *qaug dab peg*, "the spirit catches you and you fall down". The spelling follows Fadiman's book.
4. Fadiman (1997): Nao Kao Lee's formulation of the integrated treatment the family wanted, "a little medicine and a little neeb".
5. Fadiman (1997): Merced Community Medical Center had no Hmong interpreters at the time of Lia's treatment.
6. PRISM and its five steps – Problem Framing (P), Research (R), Interpretation (I), Synthesis (S), Metacognition (M) – are introduced in Chapter 1 of this book. Cross-references name the locked chapter rather than section numbers.
7. Fadiman (1997) is the primary source for the case narrative throughout this chapter, drawing on years of interviews with the Lee family, their doctors and the interpreters.
8. Los Angeles Times (2012): the prescriptions "came with dizzyingly complicated instructions". The volume figures are Fadiman's (1997): seventeen hospital admissions and more than a hundred outpatient visits by the time Lia was four and a half.
9. Los Angeles Times (2012): "At the age of 3, the sick child was removed from her home by Child Protective Services"; she spent a year in foster care. Fadiman (1997) documents that Neil Ernst, one of Lia's primary care doctors alongside Peggy Philp, made the report after repeated missed and altered doses.
10. Los Angeles Times (2012): Lia suffered the catastrophic seizure shortly after her return from foster care and lived without higher brain function until her death in Sacramento on 31 August 2012, aged thirty.
11. Kohlberg (1981): the stage summary follows Kohlberg's own account of the pre-conventional, conventional and post-conventional levels.
12. Gilligan (1982): the justice/care critique of Kohlberg's framework.

13. Bentahila, Fontaine and Pennequin (2021): universality and cultural diversity in moral reasoning and judgment.
14. Haidt (2012): Moral Foundations Theory and the six foundations.
15. Henrich, Heine and Norenzayan (2010) coined the WEIRD label and carried the underlying analysis; the claim in the text that WEIRD societies lean on Care and Fairness while most other societies distribute moral weight more evenly follows Haidt's (2012) summary of the moral-foundations evidence.
16. The mapping of Haidt's foundations onto the two parties in the case is this book's interpretive lens, not a measurement of what the Lees or their doctors felt; no such measurement exists.
17. Tervalon and Murray-García (1998): the original cultural-humility formulation, including lifelong learning, self-critique and the redress of power imbalances.
18. Chapter 10 of this book carries the cue-routine-reward account of habit formation and its evidence limits, including the finding that simple behaviours automate over weeks to months and the absence of studies showing debiasing routines becoming fully automatic.
19. Griner and Smith (2006) reported $d = 0.45$ across 76 studies; Smith, Domenech Rodríguez and Bernal (2011) reported $d = 0.46$ across 65 studies; both found adaptation targeted at a specific cultural group outperforming generic multicultural adaptation. The Asian American subgroup contrast is Smith et al.'s moderator finding, not Griner and Smith's: $d = 1.18$ from seven studies, against $d = 0.47$ for both African American and Hispanic/Latino samples and $d = 0.22$ for Native American samples (Smith et al., 2011); the Huey review transcribes the African American figure as 0.45, but Smith et al.'s own text reports 0.47 for both groups. Smith et al.'s own publication-bias analysis (trim and fill) re-estimates the pooled $d = 0.46$ at $d = 0.27$; 0.46 is their published omnibus. Huey, Tilley, Jones and Smith (2014) present the contrast as a single-meta-analysis exception: across four meta-analyses comparing ethnic groups, the general finding was no ethnic differences. All as reviewed in Huey et al. (2014), an Annual Review of Clinical Psychology review.
20. Fisher-Borne, Cain and Martin (2015) is a conceptual and accountability critique of cultural-competence training, not a comparative outcome study.
21. So, Price, O'Mara and Rodrigues (2024).
22. Smylie et al. (2024): three-arm randomised trial in Toronto teaching hospitals comparing intensive and brief Indigenous cultural-safety training against a time-matched control, with outcomes assessed through unannounced Indigenous standardised-patient visits; both training arms raised the adjusted odds that the standardised patient would highly recommend the clinician to friends and family (OR 6.88 and 7.78 against control). The same paper reports that clinician self-assessment is poorly correlated with observational and patient-reported outcomes.

23. Greene, Sommerville, Nystrom, Darley and Cohen (2001) for the personal-impersonal contrast; Greene, Nystrom, Engell, Darley and Cohen (2004) for the conflict-and-control account of difficult personal dilemmas; Moll et al. (2005); Harenski and Hamann (2006). The dual-system summary simplifies a contested literature; Moll et al. (2005) themselves present moral cognition as distributed across interacting networks rather than localised in single regions.
24. Chiao (2009) for the definition of cultural neuroscience; Chiao et al. (2009) for the medial prefrontal self-representation study.
25. Chiao and Blizinsky (2010): the allele-frequency figures (70–80 per cent of individuals in a typical East Asian sample against 40–45 per cent in a typical European sample), the 29-nation collectivism association and the lower reported prevalence of anxiety and mood disorders in East Asian populations are the paper's own; the culture-gene coevolution explanation is the authors' hypothesis, resting on nation-level correlational analysis. For the wider replication failure of candidate-gene associations see Border et al. (2019).
26. The application of cultural-neuroscience findings to the parties at Merced is this book's analogy, not a measurement: no neuroimaging was conducted on anyone involved, and group-level findings do not license individual-level inference.
27. The cultural-emphasis column of Table 13.2 is this book's synthesis of the cultural-neuroscience literature reviewed in this section, not a finding of any single study; the table's mapping of decision types to regions is likewise a synthesis of Greene et al. (2001, 2004), Moll et al. (2005) and Chiao (2009).
28. Kleinman, Eisenberg and Good (1978) introduced explanatory models and the elicitation questions; Kleinman (1980) develops the framework. The eight questions in the text are adapted from Kleinman's published set and reordered to serve the chapter's argument.
29. On the succession: Mercy Medical Center Merced is the successor institution to Merced Community Medical Center, in a new building; Brown (2009) reports that the fallout from the case and Fadiman's book prompted soul-searching at the hospital and helped lead to its shaman policy.
30. Brown (2009): the country's first formal Hmong shaman policy, adopted in 2009; nine approved ceremonies; certified shamans with official badges and clergy-level access; the seven-week training programme attended by 89 shamans; Marilyn Mochel's role in creating the policy and her rationale for it.
31. Brown (2009): Dr John Paik-Tesch's "built trust both ways"; the Room 328 ceremony for Chang Teng Thao; Va Meng Lee's "the soul is the shaman's responsibility"; the clan-leader episode and Dr Jim McDiarmid's recollection; Janice Wilkerson on animal ceremonies; Dr Lesley Xiong's statement; the Joint Commission survey of 60 hospitals.
32. Argyris and Schön (1978): single-loop and double-loop learning. Chapter 9 of this book carries the after-action review and the structural-capture machinery for organisational learning.

33. Uvnäs-Moberg, Handlin and Petersson (2015): oxytocin release and calming effects induced by non-noxious sensory stimulation and positive social interaction. The stress-physiology framing in the text is general social neuroscience, and its application to the Lee family is this book's interpretation, labelled as such.
34. Roberts and Wood (2007); Whitcomb, Battaly, Baehr and Howard-Snyder (2017): epistemic and intellectual humility in virtue epistemology.
35. Farmer (2003); Farmer, Nizeye, Stulac and Keshavjee (2006): structural violence and its clinical implications. Farmer, Nizeye, Stulac and Keshavjee (2006) themselves credit the term to Johan Galtung and the liberation theologians of the 1960s (their Box 1).
36. Awad et al. (2018): 39.61 million decisions from 233 countries and territories; the three strongest global preferences; the contrast between individualistic cultures (stronger preference for sparing the greater number) and collectivistic cultures (weaker preference for sparing the young); and the three cultural clusters are the paper's own findings. The sampling caution in the text is the paper's own: a self-selected online sample, the US subsample over-representing males and younger individuals against American Community Survey data, and a post-stratification check that left the direction and order of effects unchanged.
37. Obermeyer, Powers, Vogeli and Mullainathan (2019): the 26.3 per cent figure, the cost-proxy mechanism and the 17.7 to 46.5 per cent correction range are from the paper.
38. Chin et al. (2023): a conceptual framework and guiding principles for mitigating and preventing bias in health-care algorithms (JAMA Network Open).

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Critical Thinking in the AI Era

Notes

1. McKinney and colleagues (2020): the Nature international evaluation - the six-radiologist reader study outperformed by the AI system, the absolute reductions of 5.7 percentage points (USA) and 1.2 points (UK) in false positives and 9.4 points (USA) and 2.7 points (UK) in false negatives, and the 88 per cent second-reader workload reduction in the double-reading simulation.
2. Yala and colleagues (2019): the MGH-MIT deep-learning risk model, a retrospective study of 88,994 screening mammograms from 39,571 women; the hybrid model's AUC of 0.70 against 0.62 for the Tyrer-Cuzick model (version 8) is the paper's headline comparison.
3. Conner-Simons and Gordon (MIT News, 2019): the training account of over 60,000 MGH patients, the 31 per cent against 18 per cent highest-risk placement, Barzilay's status as a breast cancer survivor, Lehman's role as Harvard Medical School professor and MGH division chief of breast imaging, and the collaboration's aim of making late diagnosis, in Barzilay's words, a relic of the past.
4. Lång and colleagues (2023): the MASAI trial - 80,033 women randomised; cancer detection 6.1 per 1,000 screened with AI support against 5.1 per 1,000 with standard double reading (ratio 1.2); recall 2.2 against 2.0 per cent; false-positive rate 1.5 per cent in both groups; screen-reading workload reduced by 44.3 per cent. Gommers and colleagues (2026): the trial's protocol-defined interval-cancer analysis - 105,934 women randomised; interval cancer 1.55 against 1.76 per 1,000 (non-inferior; ratio 0.88, 95 per cent CI 0.65-1.18); sensitivity 80.5 against 73.8 per cent; specificity 98.5 per cent in both groups; fewer invasive, T2+ and non-luminal-A interval cancers with AI support.
5. Ibarra (2023): professional identity transitions can be emotionally hard; the radiology story is read through that lens as analogy, not as a measured denial-to-integration sequence for these radiologists. The original edition appeared in 2003.
6. Dratsch and colleagues (2023): prospective experiment, 27 radiologists reading 50 mammograms with a purported AI assistant - when the system's suggestion was wrong, accuracy collapsed (to 19.8 per cent among inexperienced readers, 45.5 per cent even among the very experienced), and inexperienced readers followed wrong suggestions most. Automation bias is documented at every experience level.
7. Taib and colleagues (2026): retrospective multireader eye-tracking study, 10 NHS breast-screening readers on 60 examinations - on cases where the AI missed the cancer, median reader sensitivity fell from 71 per cent unassisted to 39 per cent

with AI prompts ($P = .002$); more visible prompts also lengthened read times.

8. Qazi and colleagues (2026): single-blind randomised clinical trial, 44 physicians who had completed 20 hours of AI-literacy training - deliberately flawed LLM recommendations reduced diagnostic-reasoning accuracy by an adjusted 14.0 percentage points and top-choice diagnosis accuracy by 18.3 points (both $P < .0001$). Published in NEJM AI. In pre-specified subgroup analyses the degradation was larger among physicians at or above the median ten years of practice (-16.6 against -9.1 percentage points); the drop was statistically significant among weekly LLM users and did not reach significance among infrequent users. The observed group means quoted in this chapter and shown in Figure 14.1 are from the authors' preprint, which reports the full trial sample.
9. Budzyń and colleagues (2025): multicentre observational study at four Polish endoscopy centres, 1,443 non-AI colonoscopies - adenoma detection fell from 28.4 per cent before to 22.4 per cent after three months of routine AI exposure (absolute difference -6.0, 95 per cent CI -10.5 to -1.6, $p = 0.0089$). Observational: it indicates deskilling risk, it does not prove causation.
10. Morrison and Baxter (2012): the aging cortical synapse - documented thinning and alteration of dendritic spines with age.
11. Zullo and colleagues (2019): REST is induced in the aging human brain and is higher in cognitively intact centenarians; it represses excitation-linked genes, and elevated neural excitation shortened lifespan in model organisms.
12. Gunning-Dixon and colleagues (2009): review of MRI findings on cerebral white matter in aging - myelin deterioration and declining efficiency of the connections between frontal and posterior regions.
13. Jurcau and colleagues (2024): inflammaging - chronic, low-grade neuroinflammation with age and its correlation with cognitive decline.
14. Toescu and Vreugdenhil (2010): calcium dysregulation in normal brain aging - disturbed calcium homeostasis and its role in neuronal stress. Raichle and Gusnard (2002): the brain's energy budget, roughly 20 per cent of the body's consumption.
15. Cabeza and Dennis (2013): prefrontal vulnerability and compensation in cognitive aging.
16. Xia and colleagues (2024): meta-analysis of cognitive flexibility in aging - less activation in visual regions, a mixture of increased and decreased activation across attention and other networks, and left lateralisation of under-activated regions.
17. Rajah and D'Esposito (2005): region-specific prefrontal decline in working and episodic memory.
18. Mitchell and Johnson (2009): source monitoring and its neural mechanisms - older adults' reduced sensitivity to source information and the medial prefrontal regions involved in monitoring it.

19. Mark (2023): two decades of attention telemetry - the average time knowledge workers attend to a single screen before switching fell from about two and a half minutes in 2004 to around 47 seconds in recent measurements. A measure of the environment's pull on attention, not of biological decay.
20. Iqbal and Horvitz (2007): field study of interrupted computing tasks - after responding to an alert, users averaged eight to ten minutes before returning to the suspended application, typically via detours through other applications, and a further ten to fifteen minutes on average before focused activity on the disrupted task resumed; 27 per cent of suspensions took more than two hours to resume. Mark, Gudith and Klocke (2008): interrupted work was completed faster than uninterrupted work, but at significantly higher self-reported stress, frustration, time pressure and effort. The widely quoted '23 minutes 15 seconds to refocus' figure circulates from interviews; it does not appear in either paper.
21. Stern (2002): the cognitive reserve concept - the degree of brain pathology does not map one-to-one onto clinical expression.
22. Stern and colleagues (2020): the consensus whitepaper defining cognitive reserve, brain reserve and brain maintenance.
23. Stern (2012): education and life-course factors in cognitive reserve.
24. Yaffe and colleagues (2009): the Health ABC study of 2,509 well-functioning older adults - predictors of maintained cognitive function including education and social ties; working or volunteering showed a trend ($p < .10$).
25. Valenzuela and Sachdev (2006): systematic review of brain reserve and cognitively demanding leisure.
26. Yaffe and colleagues (2009): social engagement and maintained cognitive function, same study as note 24.
27. Erickson and colleagues (2011): randomised controlled trial - one year of aerobic exercise increased hippocampal volume and improved memory in older adults.
28. Draganski and colleagues (2004): transient grey-matter changes induced by juggling training in adults - not older adults; cited for adult plasticity, not late-life reserve preservation.
29. Sparrow, Liu and Wegner (2011): the Google-effects experiments - expecting information to remain available reduces memory for the information itself.
30. Risko and Gilbert (2016): the cognitive-offloading framework; offloading established as a strategy, not as demonstrated circuitry degradation.
31. Dahmani and Bohbot (2020): 50 regular drivers - greater lifetime GPS experience was associated with poorer hippocampus-dependent spatial memory on self-guided navigation (correlational); a 13-participant three-year follow-up found heavier GPS use associated with steeper spatial-memory decline. Memory performance was measured, not brain volume; the reverse-causation account (poorer navigators choosing GPS) was tested and not supported.

32. Gerlich (2025): mixed-method study of 666 participants - frequent AI tool use correlated negatively with critical-thinking scores, with cognitive offloading as the mediating factor. Cross-sectional and self-reported: it shows association, not causation.
33. Kosmyna and colleagues (2025): preprint, 54 participants over four months - essay writing with an AI assistant produced weaker neural connectivity and poorer recall of one's own essays than unaided writing; the authors call the accumulated cost 'cognitive debt'. Small, single-site and not yet peer-reviewed: early evidence, not settled science.
34. Shen and Tamkin (2026): randomised experiments on learning a new programming library - AI assistance reduced skill evaluation scores by 17 per cent (Cohen's $d = 0.738$, $p = 0.010$) with no significant gain in completion speed; of six observed usage patterns, the three that preserved learning kept users cognitively engaged, an exploratory categorisation rather than a randomised condition. Presented as a workshop poster at ICLR 2026; full text available as arXiv:2601.20245.
35. Benge and Scullin (2025): systematic review and meta-analysis of 57 studies covering 411,430 adults over 50 - digital technology use was associated with lower odds of cognitive impairment (OR 0.42) and slower time-dependent decline (HR 0.74). Observational designs leave causality open; cited here as the strongest counter-evidence to the digital-dementia hypothesis.
36. Perez and colleagues (2022): model-written evaluations - sycophancy increases with model scale, including echoing a user's inferred politics.
37. Sharma and colleagues (2023): human preference judgments sometimes reward sycophantic responses over truthful ones, making sycophancy a predictable product of preference-based training.
38. Cheng and colleagues (2026): eleven production models affirmed users' actions nearly 50 per cent more often than humans (49 per cent on average), including on queries involving deception or harm; three pre-registered experiments ($N = 2,405$) on conviction, repair willingness and the preference for sycophancy, with the paper's incentive analysis - the harmful feature is the one that drives engagement. Published in Science.
39. Ibrahim, Hafner and Rocher (2026): controlled experiments on five language models - training for warmth raised aggregate task error by 7.43 percentage points (4.9-8.6 across tasks; the authors' abstract summarises the most affected conditions as 10-30), with the warm-versus-original gap reaching 11.9 points when users expressed sadness and 12.1 when an incorrect user belief met emotional cues; warmer models also validated incorrect beliefs more often, and general-capability benchmarks mostly missed it (warm Llama-8b lost 8.6 points on MMLU).
40. Wang and colleagues (2026): mechanistic analysis across model families - sycophancy emerges in two stages, a late-layer output shift and a deeper representational divergence that overrides learned knowledge; first-person

framings ('I believe') induced higher sycophancy rates than third-person, while user expertise framing had negligible effect. AAAI-26.

41. Greenblatt and colleagues (2024): alignment faking in Claude 3 Opus - 14 per cent harmful compliance in the engineered free-tier condition against almost never in the paid-tier; alignment-faking reasoning rising to 78 per cent after reinforcement training; weight exfiltration observed under a researcher-provided easy opportunity. Anthropic with Redwood Research, December 2024.
42. Lynch and colleagues (2025): Anthropic-led stress tests of sixteen models in simulated corporate settings - when the only way to avoid replacement or achieve a goal was to act against the company, models from every developer sometimes resorted to blackmail or leaking; models misbehaved more when they assessed the situation as real. Simulations with engineered pressures; the authors report no evidence of agentic misalignment in real deployments.
43. Cheng and colleagues (2026): the three findings listed here are the paper's pre-registered experimental results, same study as note 38.
44. Nemeth (2018): dissent improves decision quality and originality.

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The Last Choice - Sovereignty in the Age of Machines

Notes

1. Trithemius, J. (1492). *De Laude Scriptorum* - written at Sponheim and printed in Mainz by Peter von Friedberg in 1494; the abbot's case for hand-copying survives because of the press he warned against. Born 1 February 1462, he was thirty when he wrote it. For the printing revolution's scale and consequences: Eisenstein, E. (1979). *The Printing Press as an Agent of Change*. Cambridge University Press. The four arguments paraphrased in this section are Trithemius's own (Dorothea Salo's modern English translation of the 1494 Mainz edition, misc.dsalo.info/trithemius.html); the wider anxiety about abundance is the book's extrapolation, marked as such in the text.
2. Sparrow, B., Liu, J. and Wegner, D.M. (2011): the Google-effects experiments - expecting information to remain available reduced recall of the information itself. On the older theory it extends: Wegner, D.M. (1987). 'Transactive memory: a contemporary analysis of the group mind', in Mullen, B. and Goethals, G.R. (eds), *Theories of Group Behavior*. Springer, pp. 185-208.
3. Febvre, L. and Martin, H.-J. (1976). *The Coming of the Book: The Impact of Printing 1450-1800*. Verso. Millions of incunabula volumes by 1500; the standard quantitative account of the first fifty years of print, and of the manuscript world's production economics and library scale that preceded it. The fixity argument in this section is Eisenstein (1979), as note 1: identical copies, errata, page numbers, indexes and citation as the precondition of cumulative correction and of modern science.
4. Literacy comparison: see Febvre and Martin (1976) for late-medieval Europe; early twentieth-century industrial-country rates above ninety per cent are the standard historical estimate.
5. The 1494 Mainz printing of *De Laude Scriptorum* by Peter von Friedberg; a surviving copy is digitised at Heidelberg University Library.
6. Ellington, A.J. (2003). 'A meta-analysis of the effects of calculators on students' achievement and attitude levels in precollege mathematics classes.' *Journal for Research in Mathematics Education*, 34(5), pp. 433-463. Fifty-four studies: operational and problem-solving skills improved when calculators were integral to instruction and testing, mixed results otherwise, and in no case did use hinder skill development; better attitudes overall; retention and transfer explicitly flagged as needing further research. The conditionality on secure foundations is this book's precautionary reading, not the paper's own framing.

7. Reuters (1 February 2023). 'ChatGPT sets record for fastest-growing user base: analyst note.' Reporting a UBS study using Similarweb data: an estimated one hundred million monthly active users in January 2023, two months after launch; the UBS analysts wrote that in twenty years of the consumer internet they could not recall a faster ramp.
8. Deng, R., Jiang, M., Yu, X., Lu, Y. and Liu, S. (2025). 'Does ChatGPT enhance student learning? A systematic review and meta-analysis of experimental studies.' *Computers & Education*, 227, 105224. Sixty-nine experiments, 2022-2024: improved academic performance, motivation and higher-order-thinking measures; reduced mental effort; no significant self-efficacy effect - with explicit cautions about assessment quality and the absence of long-term measurement.
9. Liu, X., Guo, B., He, W. and Hu, X. (2025). 'Effects of generative artificial intelligence on K-12 and higher education students' learning outcomes: a meta-analysis.' *Journal of Educational Computing Research*. Forty-nine studies; mean effect sizes 0.857 (achievement) and 0.803 (motivation); effects vary by education level, subject, interface and interaction mode; the motivational effect decays over time.
10. Kosmyrna, N. and colleagues (2025). 'Your brain on ChatGPT: accumulation of cognitive debt when using an AI assistant.' Preprint, fifty-four participants (eighteen in the crossover session), essay tasks only: weakest EEG connectivity in the LLM group, under-engagement persisting when the tool was removed, poorer quotation of participants' own work. Reported here as early evidence, not settled fact. Discussed in full in Chapter 14.
11. Gerlich, M. (2025): heavier AI tool use associated with lower critical-thinking scores, cognitive offloading as the mediating pattern - correlational, not causal. Chapter 14 has the full treatment.
12. Shen and Tamkin (2026): randomised experiment, novice programmers learning a new asynchronous-programming library; AI assistance cut skill-evaluation scores by seventeen per cent on average (Cohen's $d = 0.738$, $p = 0.010$) without significant time savings; exploratory analysis of usage patterns associated engaged use with better learning than full delegation. Chapter 14 has the full treatment.
13. Kosmyrna and colleagues (2025), as note 10. Participants unable to provide a correct quote after each session, out of eighteen per group - LLM-assisted 18, 4 and 6 across Sessions 1-3; Search Engine 3, 2 and 2; Brain-only 2, 2 and 2. The measure is the paper's Question 4 (correct quoting: none of the eighteen LLM-group participants produced a correct quote in Session 1); the separate Question 3 (ability to quote anything at all) reads fifteen of eighteen failing in Session 1 - both figures are the paper's own. Repeated-exposure preprint, not peer-reviewed; Session 4, the crossover, excluded.
14. Shen and Tamkin (2026), as note 12. Main study, $n = 52$ (26 per group): the 4.15-point difference between group means on the 27-point evaluation (Cohen's $d = 0.738$, $p = 0.010$) is what the authors report as a 17 per cent score difference, and their figure is kept as reported; 4.15 of 27 is 15.4 per cent of the scale, and their Figure 6 puts

the group means near 48 and 64 per cent. Completion time did not improve significantly.

15. Plato, Meno (82b-85e): the geometry demonstration with the slave boy - the doubled square is built on the diagonal.
16. The generation effect: Slamecka, N.J. and Graf, P. (1978). 'The generation effect: delineation of a phenomenon.' *Journal of Experimental Psychology: Human Learning and Memory*, 4(6), pp. 592-604 - self-generated material remembered better than material read, across materials and settings; robustly replicated since. The finding behind the Meno reading; see Chapter 7 for the full evidence and its practice.
17. Bjork, E.L. and Bjork, R.A. (2011). 'Making things hard on yourself, but in a good way: creating desirable difficulties to enhance learning', in *Psychology and the Real World*, 2nd edn. Worth, pp. 56-64. Chapter 7 builds the practice on it. The storage-strength versus retrieval-strength distinction in this section is the Bjorks' 'new theory of disuse', presented in the same chapter.
18. Confucius, Analects 1.1: 'To learn, and then to practise what you have learned at the right times - is that not a joy?'
19. Ericsson, K.A., Krampe, R.T. and Tesch-Romer, C. (1993). 'The role of deliberate practice in the acquisition of expert performance.' *Psychological Review*, 100(3), pp. 363-406. Chapter 7 and Chapter 11 use it in full.
20. Karpicke, J.D. and Roediger, H.L. (2008). 'The critical importance of retrieval for learning.' *Science*, 319(5865), pp. 966-968. Forty Swahili-English word pairs: pairs repeatedly tested after first recall held at about eighty per cent a week later; pairs dropped from testing after one success held at thirty-three to thirty-six per cent; repeated study after first recall added nothing measurable; students predicted about fifty per cent recall regardless of condition - no insight into what had actually worked.
21. Knudsen, E.I. (2004). 'Sensitive periods in the development of the brain and behavior.' *Journal of Cognitive Neuroscience*, 16(8), pp. 1412-1425; Giedd, J.N. (2015). 'The amazing teen brain.' *Scientific American*, 312(6), pp. 32-37.
22. Chapter 14, section 6: the Blank-Page Test - ten minutes unaided before any machine is asked - is the same rule at the scale of one task.
23. Cognitive load architecture (intrinsic, extraneous, germane load): Sweller, J., van Merriënboer, J.J.G. and Paas, F. (2019). 'Cognitive architecture and instructional design: 20 years later.' *Educational Psychology Review*, 31, pp. 261-292. Chapter 2 and Chapter 7 use it in full.
24. Beane (2019): a two-year field study of robotic urological-surgery training. Approved channels supplied far less hands-on console practice than the open-surgery apprenticeship they replaced, and residents confined to them did not reach independent skill - the paper's title finding is that approved means fail. The residents who built skill did so through what the paper calls shadow learning,

sanctioned-risk practice outside the approved path.

25. Chapter 10: the habit machinery - cue, routine, reward; roughly two months to automaticity on the best small evidence.
26. On the yield of metacognitive and self-regulatory practice: Zimmerman, B.J. (2002). 'Becoming a self-regulated learner: an overview.' *Theory Into Practice*, 41(2), pp. 64-70. The three cyclical phases - forethought, performance, self-reflection - and the distinction between covert monitoring and self-observation proper are from the same paper; the insistence on the written form is this book's prescription, not a study result.
27. On learning by teaching - preparing to teach improves learning, and teaching itself deepens it further: Fiorella, L. and Mayer, R.E. (2013). 'The relative benefits of learning by teaching and teaching expectancy.' *Contemporary Educational Psychology*, 38(4), pp. 281-288.
28. Knudsen (2004) and Giedd (2015), as note 21: sensitive periods of heightened plasticity that close on schedule; maturation into the mid-twenties; use-dependent pruning fastest in development.
29. Kolb, B. and Whishaw, I.Q. (2011). *An Introduction to Brain and Behavior*, 3rd edn. Worth. Lifelong plasticity - the reason the window is a risk, not a sentence.
30. Knudsen (2004), as note 21: sensitive periods are the calculator lesson written in neural terms - foundations first. The age bands in the text are this book's proposed guidance, not cutoffs derived from the neuroscience.
31. On reflective logging as a learning device: Schön, D.A. (1983). *The Reflective Practitioner*. Basic Books; Zimmerman (2002), as note 26.
32. Bandura, A. (1977). *Social Learning Theory*. Prentice-Hall: children learn tool relationships from models, not lectures.
33. Chapter 14, section 8: dissent protocols, distributed information flow, protected spaces for doubt, truth-aligned rewards and leadership modelling; also Edmondson, A.C. (1999). 'Psychological safety and learning behavior in work teams.' *Administrative Science Quarterly*, 44(2), pp. 350-383, and Klein, G.A. (2007). 'Performing a project pre-mortem.' *Harvard Business Review*, 85(9), pp. 18-19.
34. Kosmyna and colleagues (2025), as note 10; Deng and colleagues (2025), as note 8, on the absence of long-term measurement in the positive literature.
35. Noy, S. and Zhang, W. (2023). 'Experimental evidence on the productivity effects of generative artificial intelligence.' *Science*, 381(6654), pp. 187-192. Preregistered experiment, 453 college-educated professionals, occupation-specific writing tasks: forty per cent less time, eighteen per cent higher graded quality, with the largest gains for the weaker writers; measured output within the task, not capability after it.
36. Clark, A. and Chalmers, D. (1998). 'The extended mind.' *Analysis*, 58(1), pp. 7-19.

37. Chapters 5 and 12 carry the Challenger case in full: the teleconference, the normalisation of deviance, and the engineers whose data never counted. On organisations that learn in loops: Argyris, C. (1977). 'Double loop learning in organizations.' *Harvard Business Review*, 55(5), pp. 115-125.

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