

Index

- abductive reasoning, 17, 19, 239
- accepted fact. *See* authoritative record
- access, 122
- accuracy, 4, 120, 239
 - of demonstrative tangible evidence, 120–121
- agent *See* cognitive assistant
- aleatory probability, 174
- Allemang, Dean, 227, 234
- ambiguous evidence, 239
- analysis, 85, 239
- analysis and synthesis, 84–90
 - inquiry-driven, 86
- ancillary evidence, 199, 239
- Anderson, Terence, 149
- Angleton, James J., 159
- anomaly, 37, 239
- approximate reasoning, 203
- archiving, 32
- argument, 16, 239
 - direction, 9
 - force, 9
 - problems with construction, 90–93
- assumption, 198, 200, 239
- authenticity, 4, 120, 240
 - of demonstrative tangible evidence, 120
 - of real tangible evidence, 120
- authoritative record, 128
- auxiliary evidence. *See* ancillary evidence

- Bacon, Francis, 197
- Baconian inference
 - different tests of hypotheses, 197
 - eliminating hypotheses, 197
- Baconian probability system, 22, 197–202, 240
 - compared with others, 205–208
 - evidential completeness, 197–201
 - example, 202
 - intersection, 201
 - negation, 201
 - union, 201
- Baring-Gould, William S., 28
- Bayes, Thomas, 176
- Bayes' rule, 176
 - and assumptions, 199
- Bayesian networks, 183–189
 - constructing argument structure, 183
 - forming key list, 183
 - identifying probabilities, 184
 - use of, 187
- Bayesian probability system, 10, 177–189, 240
 - and assumptions, 199
 - compared with others, 205–208
- Belief Functions, 10, 189–197, 240
 - and assumptions, 199
 - compared with others, 205–208
 - evidential support, 189–192
 - examples, 192–193
- believability, 23, 65–67, 240
 - versus credibility, 67
 - of demonstrative tangible evidence, 121
 - of evidence, 3
 - example, 4
 - of source, 3, 9
 - of testimonial evidence, 124
- believing as-if. *See* assumption
- Betham, Jeremy, 236
- bias, 213–224, 240
 - absence of evidence, 215
 - of analyst, 219
 - in chains of custody, 220–221
 - mitigation with Disciple-CD, 221
 - of consumers of intelligence, 221–222
 - mitigation with Disciple-CD, 221
 - definition, 214
 - and evaluation of analysts, 222–223
 - in estimating probabilities, 217–218
 - mitigation with Disciple-CD, 218
 - in evaluation of evidence
 - mitigation with Disciple-CD, 215–216
 - hindsight in evaluating intelligence reports, 218–219
 - mitigation with Disciple-CD, 219
 - of HUMINT sources, 219–220
 - mitigation with Disciple-CD, 220
 - objectivity, 220
 - observational sensitivity, 220
 - veracity, 220
- interpretation, 213–214
 - in electrical engineering, 213
 - in law, 214

- bias (cont.)
 - origin, 213
 - in statistics and machine learning, 213
 - synonyms, 214
- mitigation with Disciple-CD, 223
- in perception of cause and effect, 216–217
 - mitigation with Disciple-CD, 217
- big data, 5, 240
- Black, H. C., 214
- Boicu, Mihai, 109, 226–227
- Bonaparte, Napoleon, 151
- Bruce, J. B., 66, 221

- center of gravity determination, 227
- chain of custody, 33, 66, 139–147, 240
 - analysis, 146
 - drill-down analysis, 147
 - for tangible evidence, 143–146
 - for testimonial evidence, 141–143
 - typical INT chains, 141
- chain of reasoning. *See* argument
- chance, 175
- Chantrell, G., 213
- circumstantial evidence, 162, 241
- Clemen, R. T., 223
- Clemente, J. D., 223
- cognitive assistant, 45, 86, 146, 223, 225–236
 - development, 231–236
 - ontology, 232
 - optimization, 236
 - rapid prototyping, 232
 - rule learning and ontology refinement, 234
 - specification, 231
 - use and personalization, 235
- cognitive bias. *See* bias
- Cohen, Jonathan L., 197, 208
- combination, 241
- combinatorial explosion, 6
- COMINT, 148
- competence, 4, 122, 241
 - versus credibility, 122
 - of HUMINT, 122–123
- competing hypotheses, 20
- completely equivocal testimonial evidence, 125
- computational theory of intelligence analysis, 26
- concept, 227
- conclusive evidence, 161–162, 241
 - and nugget, 162
- conditional dependence, 180, 186
- conditional nonindependence. *See* conditional dependence
- conditional probability, 178
- conjunction, 241
- connecting the dots, 1–12, 241
 - definition, 1
 - example, 2
- contradictory evidence, 150, 241
 - example, 152
 - resolution, 151
- convergence, 241
- convergent evidence, 149, 241
 - example, 150
- corroborative evidence, 148, 241
 - example, 149
- corroborative redundant evidence, 152, 241
 - example, 153
- credential of evidence, 241
- credibility, 123, 242
 - versus believability, 67
 - versus competence, 122
 - of HUMINT, 123–124
- critical reasoning, 3, 13, 242
- cumulative redundant evidence, 153, 242
 - example, 153–154
- current intelligence, 160, 242
- customer, 11
- cybersecurity, 228, 236

- Dale, E., 176
- Danzig, R., 109
- data, 242
- David, F. N., 175
- deduction, induction, and abduction, 5
- deductive reasoning, 17, 242
- deep believability analysis, 130–133
 - objectivity questions, 132
 - examples, 131
 - observational sensitivity questions, 133
 - examples, 132
 - veracity questions, 130
 - examples, 131
- defensible and persuasive argument, 65, 242
- defensible argument, 9
- demonstrative tangible evidence, 120, 242
- Dempster's rule, 193–197
 - example, 194
- desk analyst, 221
- Deuteronomy, 151
- direction, 242
- directly relevant evidence, 242
- disbelief. *See* lack of belief
- Disciple-CD, 4, 9–11, 45–48, 229–231
 - assumption module, 46
 - description module, 48, 57
 - domain KB, 49
 - evidence module, 46
 - hypothesis module, 45
 - installation folder, 49
 - knowledge manager, 50
 - reasoner module, 46
 - reference KB, 52
 - scenario KB, 49
 - system overview, 45
- Disciple-EBR, 225, 228–229
- Disciple-LTA, 66
- discovery, 242
 - and inquiry, 30
 - of new ideas, 29
 - and search, 30
- disfavoring evidence, 243

- disjunction, 242
- disproof, 197
- dissonant evidence, 150–152, 243
 - definition, 150
- divergent evidence, 151, 243
 - example, 152
- divide and conquer, 83, 243
 - analysis, 82–93
- dots
 - evidential, 2–3
 - combinations of, 5
 - idea, 3, 5, 8–9
- Drogin, B., 216

- eliminative induction, 243
- emergency response planning, 227
- enumerative probabilities, 174–177
- epistemology, 243
- equivocal testimonial evidence, 125
- ERGO, 187
- evidence, 59–73, 243
 - classification of, 119
 - credentials of, 62
 - definition, 16, 62
 - extracted from information, 168–170
 - and law, 61
 - versus
 - data, 59
 - event, 3, 118
 - fact, 59
 - item of information, 59
 - knowledge, 60
- evidence collection task, 21
- evidence custodian, 66, 139, 220, 244
- evidence in search of hypotheses, 59–73, 244
- evidence uncertainty
 - ambiguity, 163–165
 - examples, 164–165
 - dissonance, 165–166
 - examples, 166
 - imperfect believability, 166–167
 - examples, 166–167
 - incompleteness, 11, 159–162
 - examples, 160–162
 - inconclusiveness, 162–163
 - examples, 163
- evidence-based hypothesis assessment, 243
- evidence-based reasoning
 - in cybersecurity, 236
 - in forensics, 236
 - in intelligence analysis, 236
 - in law, 236
 - in medicine, 236
 - in natural sciences, 236
 - as revision of probabilistic beliefs, 173
- evidential synergism, 7, 11, 63
 - example, 5–6
- evidentiary testing of hypothesis, 22–23, 244
- expert analyst, 225
 - fact, 244
- favoring evidence, 244
- federal rules of evidence, 62
 - and believability, 66
 - and relevance, 62
- financial services, 227
- frame, 191
- frame of discernment, 191
- Fuzzy force of evidence, 204
- Fuzzy probability system, 22, 202–205, 244
 - compared with others, 205–208
 - intersection, 204
 - negation, 204
 - union, 204

- Gates, Bill, 227
- generalization, 199, 244
 - hierarchy, 234
 - maximal, 234
 - minimal, 234
- George, R., 221
- giving benefit of the doubt. *See* assumption guideline
 - analysis development, 114
 - identify instances and constants, 114
 - learn and reuse patterns, 115
 - one KB in memory, 52
 - save successive KB versions, 52
 - short names for abstract hypotheses, 115

- hands-on exercise
 - abstraction of analysis, 102–104
 - analysis browsing, 53–58
 - analysis with evidence combinations, 154–156
 - argument development, 98–101
 - believability analysis, 133–136
 - complex analysis, 167–170, 208–211
 - evidence definition and evaluation, 148–150
 - evidence search, 104–108
 - hypothesis analysis, 93–98
 - information to evidence, 79–80
 - justification of assumptions, 108
 - knowledge bases, 49–52
 - pattern reuse, 101–102
 - top-down and bottom-up argument development, 109–113
- harmonious evidence, 148–150, 244
 - definition, 148
- Hendler, Jim, 227, 234
- Heuer, Richard J., 92, 213–220
- heuristic, 24, 244
 - definition, 31
- Hintikka, Jaakko K. J., 28
- holistic approach to analysis, 82–83, 244
 - example, 82
- Holmes, Mycroft, 12, 29–30, 42
- Holmes, Sherlock, 2, 6, 12, 28–29, 38, 248
- Howe, Michael J.A., 12
- HUMINT, 3–4, 32, 66–67, 124, 148, 159, 216, 244

- hypotheses in search of evidence, 19–22, 245
 - illustration, 93–96
- hypothesis, 245
 - examples, 236
 - major, 14
- hypothesis testing, 21
- hypothesis-driven evidence collection, 21
- imaginative reasoning, 3, 12–17, 19, *See* abductive reasoning
- IMINT, 3, 32, 119, 148, 245
- inconclusive evidence, 245
- indications and warnings, 34
- indicator, 88–90
 - almost certain indicator, 89
 - example, 89–90
 - likely indicator, 89
 - probability computation, 89
 - very likely indicator, 89
- indirectly relevant evidence. *See* ancillary evidence
- inductive
 - generalization, 200
 - reasoning, 17, 245
- inference, 245
- inference network, 8, 13, 245
- inferential catastrophes, 4
- inferential force or weight of evidence, 23, 67–68
 - and vividness of evidence, 215
- integrated teaching and learning, 227
- Java, 48
- Johnston, R., 221
- judgment
 - believability, 68–69
 - inferential force or weight, 68–69
 - relevance, 68–69
- Kahneman, Daniel, 217
- Keeling, Harry, 227
- Kent, Sherman, 202–203, 205, 217
- Kirkpatrick, L. C., 62, 66
- knowledge base, 49–53, 226
 - Domain KB, 229
 - Scenario KB, 229
 - Shared EBR KB, 228
- knowledge engineer, 225
- knowledge society, 227
- Kodratoff, Yves, 227
- Kolmogorov, Andrey N., 175–177, 217
- Kolmogorov's axioms of probability, 175, 178, 189–190, 193, 204
 - additivity axiom, 175
- lack of belief, 191, 196
- lack of proof, 197
- law, 61
- laws of large numbers, 175
- learning agent shell, 226
 - definition, 226
- learning by analogy, 227
- learning from examples, 227
- learning from explanations, 227
- Lempert, R. O., 120, 140
- likelihood, 184, 246
 - versus likeliness, 69
- likelihood ratio, 178–183
 - examples, 179–183
- likeliness, 246
 - versus likelihood, 69
- Lindberg, David A., 214
- lines of inquiry and evidence, 29
- MACE, 33
- Marrin, Stephen P., 223
- marshaling, 246
 - evidence, 29
 - thoughts, 29
- marshaling magnet, 30–42, 246
 - argument magnet, 37–38, 239
 - believability magnet, 32, 240
 - chronology magnet, 33–35, 240
 - eliminative magnet, 38–39, 243
 - hypothesis magnet, 36–37, 244
 - question magnet, 35–36, 247
 - scenario magnet, 39–41, 247
 - use of, 41–42
- Martin, D. C., 159
- MASINT, 3, 32, 119, 246
- Meckl, Steven, 236
- meta-evidence. *See* ancillary evidence
- Michalski, Ryszard S., 227
- military course of action, 227
- missing evidence, 126–128
 - example, 127
 - versus negative evidence, 127
- mixed evidence, 128–129, 190
 - analysis of, 128
 - examples, 128
- mixed-initiative problem solving, 227
- Morris, Jon, 33
- Mueller, C. B., 62, 66
- multi-INT fusion, 23
- multistrategy learning, 227
- Murphy, Peter, 61
- narrative, 11
- Negoita, Constantin V., 203
- Nilsson, Nils J., 84
- nonenumerative probabilities, 177
- nugget, 246
- objectivity, 4, 123, 246
 - role of memory, 123
- observational sensitivity, 4, 124, 246
- odds, 175
 - posterior, 178
 - prior, 178
- odds-likelihood ratio, 178
- ontology, 226
 - of evidence, 119

- of evidence combinations, 155
 - specification, 234
- operation with assumption
 - define, 97
 - define with justification, 108
 - delete, 98
- operation with hypothesis
 - associate search criteria, 107
 - browse analysis of hypothesis, 58
 - convert between modeled and formalized, 100
 - insert hypothesis above, 112
 - introduce into abstract reasoning tree, 103
 - modify abstraction of, 104
 - move to left or right, 113
 - remove from abstract reasoning tree, 104
 - specify, 99
 - specify by instantiating pattern, 101
 - specify its reduction by reusing pattern, 101
 - update name of elementary hypothesis, 113
- operation with item of evidence
 - assess, 79
 - associate to hypothesis, 79
 - define, 76
 - define from item of information, 80
 - define with type, 136
- operation with item of information
 - define, 80
- operation with knowledge base
 - close, 52
 - create, 52
 - end case study, 58
 - load and select, 50
 - run case study, 58
 - save, 50
- operation with reasoning tree
 - define instances and constants, 100
 - delete node, 100
 - select synthesis function, 97
 - specify node, 100
- ordered symbolic probability scale, 23, 69
- parallel event chronologies, 34
- paralysis by analysis, 84
- pattern learning
 - versus rule learning, 229
- Peirce, Charles S., 17–18
- persuasive argument, 9
- possibility function, 203
- posterior belief, 173, 246
- posterior probability, 177, 185, 246
- power set, 192
- prior probability, 173, 177, 184, 246
- probabilistic judgment, 67
- probabilistically equivocal testimonial evidence, 125
- probability, 246
 - alternative views, 174
- probability scale
 - Baconian, 191, 197
 - conventional, 191
 - degree of support or belief, 191
 - productively imaginative thought, 12
 - proposition, 247
 - pure evidence, 190, 193
- Ralescu, Dan A., 203
- Rationale system, 205
- real tangible evidence, 120, 247
- reduction. *See also* analysis
 - indicator, 88
 - necessary and sufficient condition, 87
 - scenario, 88
 - sufficient condition, 88
- redundant evidence, 152–154, 247
 - definition, 152
- relative frequency, 175
- relevance, 8, 23, 62–65, 247
 - argument, 10
 - of event, 5
 - example, 63
 - FRE-401, 62
- relevant evidence, 247
 - directly relevant, 63
 - indirectly relevant, 63
 - ancillary, 63
 - auxiliary, 63
 - meta, 63
- reliability, 120, 247
 - versus believability and credibility, 67, 121
 - of demonstrative tangible evidence, 121
- reliable source, 67
- repeatable process. *See* replicable process
- replicable process, 175
- rule, 227
 - applicability condition, 234
- rule learning
 - versus pattern learning, 229
- Schum, David A., 30, 33, 66, 85, 123, 140, 149, 151, 187, 196, 207, 217, 219, 228
- science of evidence, 228
- scientific method, 17
- Semantic Web, 227, 230, 234
- sensitivity analysis, 187
- Shafer, Glenn, 67, 189–191, 193, 205, 208
- SIGINT, 3, 32, 119, 247
- Simonite, T., 227
- software assistant, 227, *See* cognitive assistant
- source of evidence, 32
- standard of proof, 247
 - balance of probability, 240
 - beyond reasonable doubt, 203, 240
 - clear and convincing evidence, 203, 241
 - preponderance of evidence, 203
 - probable cause, 203
- statistical process, 175
- subjective Bayesian. *See* Bayesian probability
 - system
- substance-blind, 248
- synergistic evidence, 149, 181, 248
 - example, 150

- synthesis, 85, 248
 - hypothesis-level, 86
 - reduction-level, 86
- synthesis function
 - almost certain indicator, 89
 - on balance, 72
 - likely indicator, 89
 - max, 70
 - min, 69
 - very likely indicator, 89
- taking something for granted. *See* assumption
- tangible evidence, 3, 119–122, 248
 - examples, 121
 - types, 120
- task decomposition. *See* analysis
- teaching, 227
- TECHINT, 119
- Tecuci, Gheorghe, 45, 66, 84, 140, 223, 225–229, 234, 238
- testimonial evidence, 3, 122–126, 248
 - believability, 122
 - examples of, 126
 - types of, 125
- testimonial evidence based on opinion, 125
 - source's inferential ability, 125
- TIACRITIS, 45
- Toulmin, Stephen E., 85, 205
- trifles, 2, 28, 248
 - combinations, 28
 - examples, 33
- truthfulness. *See* veracity
- Tversky, Amos, 217
- understandability, 122
- unequivocal testimonial evidence, 125
 - based upon direct observation, 125
 - obtained at second hand, 125
- Van Gelder, Tim, 205
- variative and eliminative inference, 197
- veracity, 4, 123, 248
- verbal assessment of probability, 204–205
 - versus numerical, 204
- W3C, 227, 234
- weight of evidence. *See* inferential force or weight of evidence
 - as degree of support, 190
- Wigmore, John H., 9, 84, 151, 203, 205
- workaround reasoning, 227
- Zadeh, Lofti, 202–204