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

257
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
evidence, 2
contradictory evidence, 150, 241
example, 152
resolution, 151
convergence, 241
convergent evidence, 149, 241
evidence, 150
corroborative evidence, 148, 241
evidence, 149
corroborative redundant evidence, 152, 241
example, 153
credential of evidence, 241
credibility, 137
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
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
## Index

- 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
- 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
designed 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 likelihood, 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
mult-INT fusion, 23
multistrategy learning, 227
Murphy, Peter, 61
narrative, 11
Negotia, 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
Index

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
modifying 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
FRI-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
Index

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
test, 33
truthfulness. See veracity
Tversky, Amos, 217
underability, 122
unequivocal testimonial evidence, 125
based upon direct observation, 125
obtained at second hand, 125
Van Gelder, Tim, 205
variate 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