



## INDEX FOR COGNITIVE SCIENCE (3RD EDITION)

- A-consciousness (access consciousness) 393–4, 444
- A-Not-B error, dynamical systems approach 161–5
- abduction (abductive reasoning) 444
- Abrams, Richard 392–3
- absolute judgment 444
- access consciousness (A-consciousness) 393–4, 444
- action potentials 9, 237, 444
- activation function 444
- activation space 301
- ACT-R cognitive architecture 220–2
  - basic structure and features 220–2
  - hybrid architecture 222–4
- ADHD 439
- Adolphs, Ralph 370
- agent, definition 204
- agent architectures 204–7
  - definition 204
  - goal-based agents 205–6
  - hybrid architectures 219–24
  - learning agents 206–7
  - massive modularity hypothesis 210–19
  - modularity of mind (Fodor) 207–10
  - reflex agents 204–5
  - simple reflex agents 204–5
- algorithms 106, 444
  - concept 22–5
  - local learning algorithms 140
  - SHRDLU program 40–7
  - in transformational grammar 27–8
- Allen robot 424–7
- AlphaGo program 327–30
- AlphaGo Zero program 329–30
- Alzheimer's disease 439
- Amazon's Alexa 318
- analytic tradition 5
- anatomical connectivity 444
- AND Boolean function 129–31
- anterograde amnesia 444
- anthropology, role in cognitive science 3–5
- architectures *see* agent architectures
- Arnheim, Rudolf 180
- artificial agents
  - architectures for 204–7
  - types of 204
- artificial intelligence (AI) 47, 100
- chatbots 39–40
  - role in cognitive science 3–5
- SHRDLU program 40–7
- strong and weak AI 118
- voice-based 318
- see also* machine learning; robotics
- artificial neural networks (connectionist networks) 77–8, 124–5, 444
  - ability to learn from “experience” 143
  - biological plausibility 139–41
  - distributed representations 141
  - Fodor-Pylyshin objection to neural network models 301–2
  - information processing 78–80
  - information storage and information processing not clearly distinguished 142–3
  - key features of information processing 141–3
  - models of children's physical reasoning 293–300
  - models of language learning 266–74
  - multilayer networks 136–41
  - neurons and network units 125–8
  - pattern recognition 78–80
  - relationship to physical symbol models 300–2
  - single-layer networks 128–36
- Aslin, Richard 275
- association 17
- attention
  - locus of selection problem 241–6
  - networks of attention 246–9
- attention effect 243
- attention selection models 241–2
- attractors 444
- autism, pretend play and 341–2
- autoencoders 322–4, 444
- autonomous vehicles 442–3
- Baars, Bernard 396–7
- backpropagation algorithm 444
- Baillargeon, Renée 287–8, 347–8
- balance beam problem, network modeling 297–300
- Banaji, Mazharin 374
- Baron-Cohen, Simon 342–6, 349–53, 373
- basins of attraction in state space 157–8
- Bayes, Thomas 172
- Bayesian language learning 274–80

- Bayesianism 444
  - basic elements 172–9
  - binocular rivalry (case study) 182–6
  - conditional probability 175–6
  - decision-making 189–90
  - degrees of belief 173
  - expected utility theory 187–90
  - neuroeconomics 186–98
  - neurons that code for expected utility 190–8
  - perception as a Bayesian problem 179–86
  - probability calculus 173–4
  - subjective probability 173–4
- Bayes's Rule 176–9, 444
  - application to language learning 274–5
  - likelihood of the evidence 178–9
  - posterior probability 178–9
  - prior probability 178–9
- behavior-based robotics 427–32, 444
- behavioral finance 186
- behaviorism 444
  - reaction against 16–22
- belief–desire psychology 107–8
- belief system 210
- Bengio, Yochua 318, 320–1, 325
- Berger, Theodore 440
- Bergson, Henri 401
- Bernoulli, Daniel 189
- Bernoulli, Nicholas 189
- Berti, Anna 387
- binary Boolean functions 128–31
- binding problem 444
- binocular rivalry 182–6, 445
- biorobotics 418–23, 445
- Bisiach, Eduardo 385
- bits 28, 50, 445
- blindsight 445
  - nonconscious processing 384–7
  - what is missing 389
- Block, Ned 393–4
- BOLD (blood oxygen level dependent) fMRI
  - signal 86–7, 240, 445
  - neural correlates 90–2
  - relation to cognition 250–1
- Boolean functions 445
  - single-layer networks 128–36
- bots 204
- bottom-up approach to study of the mind 70–6
- brain
  - activity associated with remembering visual experiences 87–9
  - default mode network (DMN) 439
  - descriptive vocabulary 72
  - functions of the lobes 68–70
- brain anatomy 68–70
  - Brodmann areas 69–70
- brain atlases 252
- brain connectivity, Human Connectome Project 438–9
- brain-damaged patients, cognitive problems 73
- brain imaging *see* neuroimaging
- brain mapping
  - anatomical connectivity 232–7
  - attention selection models 241–2
  - blood flow and blood oxygen levels 240–1
  - combining ERPs and single-unit recording 242–6
  - combining resources in networks of attention 246–9
  - combining resources in the locus of selection problem 241–6
  - EEG (electroencephalography) 237–41
  - electrical activity of the brain 237–40
  - fMRI (functional magnetic resonance imaging) 240–1
  - functional connectivity versus effective connectivity 252–3
  - functions of the lobes 232–4
  - hypotheses about visuospatial attention 248–9
  - MEG (magnetoencephalography) 240–1
  - from neuroimaging data to maps 249–53
  - neuroscientific techniques 237–41
  - noise in the neuroimaging system 251–2
  - PET (positron emission tomography) 240–1
  - relation between blood flow and cognition 250–1
  - structure and function in the brain 230–7
  - tract tracing 234
- Broadbent, Donald 28–32, 241–2, 397
- Brodmann, Korbinian 232–4
- Brodmann areas 70, 232–4, 445
- Brooks, Rodney 416–18, 423–8
- Bruner, Jerome 180
- Bussemeyer, Jerome R. 161
- bytes 50
- CAPTCHA tool 316
- Carruthers, Peter 396
- causation by content 108–10
- central cognitive processing 209–10
- cerebral cortex 445
- Chalmers, David 394–6
- Changeux, Jean-Pierre 398–400
- channel capacity 30, 445
- chatbots 39–40, 445
- cheater detection module 211–13, 445
- Cheng, Gordon 440
- Chilauksy, Richard 314–15
- child development, dynamical systems approach 158–67
- Chinese room argument 315, 452
- Chomsky, Noam 26–8, 38, 260, 265
- chunking information 30, 445

- Church, Alonzo 24–5  
 Church–Turing thesis 24–5, 445  
 Churchland, Patricia 5  
 classical/Pavlovian conditioning 16–17, 445  
 cochlear implants 440  
 cocktail party phenomenon 31–2  
 cognitive-deductive system 41–2  
 cognitive maps 21  
 cognitive model of single-word processing 82–4  
 cognitive neuroscience of mindreading 365–75  
 cognitive processes  
   central processing 209–10  
   massive modularity hypothesis 210–19  
   modular processing 208–9  
 cognitive psychology 47–8  
 cognitive science  
   aim of 10  
   functional view 66–8  
   interdisciplinary nature 3–5  
   range and scope 5–9  
   space of 10–11  
   three dimensions of variation 10  
   unified Theory of Cognition 10  
 cohesion, principle of 288–90, 451  
 Colby, Carol 248–9  
 competitive networks 140–1, 445  
 complex behaviors  
   planning and organization 21–2  
   problem of serial order 21–2  
 computation 445  
 computation theory 22–5  
 computational governor 154–6  
 computational model of motor control 159  
 computational modeling of the brain 76–80  
 computational neuroscience 124–5, 445  
 conditional probability 175–6, 445  
 conditioned stimulus 17  
 conditioning 16–17  
 congruence priming 445  
 connectionist approach to language learning 266–74  
 connectionist modelers 124–5  
 connectionist models of tense learning 269–74  
 connectionist networks *see* artificial neural networks  
 connectivity, anatomical 445  
 connectivity matrices 234  
 Connell, Jonathan 427  
 conscious awareness, information processing without 382–7  
 consciousness  
   access consciousness (A-consciousness) 393–4  
   blindsight and 384–7  
   challenge of understanding 380–1  
   conscious and nonconscious vision 389–92  
   diversity of research approaches 400–1  
   easy and hard problems of 394–6  
   global workspace theory of 396–400  
   inadequacy of information-processing models of the mind 380–1  
   Knowledge Argument 380–1  
   phenomenal consciousness (P-consciousness) 393–4  
   priming and 382–4  
   two types of 393–4  
   unilateral spatial neglect and 384–7  
   what is missing in blindsight and spatial neglect 389  
   what is missing in masked priming 392–3  
   what it is for 387–93  
 contact, principle of 289–90, 451  
 contention scheduling 397  
 continuation, principle of 181  
 continuity, principle of 451  
 continuity constraint 290  
 contralateral organization 445  
 convolutional neural networks (ConvNets) 324–7, 446  
   invariance under translation 326–7  
   shared weights 326  
   sparse connectivity 325–6  
 Cooper, Lynn 47–8  
 cooperation, evolution of 213–15  
 co-opted mechanisms, role in mindreading 369–75  
 co-opted systems 446  
 Corbetta, Maurizio 249  
 corpus callosum 446  
 Cosmides, Leda 211, 213–14, 216–18  
 counterfactual thinking 362, 446  
 Courville, Aaron 325  
 covert attention 246, 249, 446  
 Cox, James 212–13  
 cricket phonotaxis 419–20  
 cross-lesion disconnection experiments 73–6, 446  
 cross-talk 446  
 Damasio, Antonio 396  
 Darwinian modules 210–11  
   cheater detection module 211–13  
 Dayan, Peter 330  
 Decision Field Theory 161  
 decision-making, Bayesian approach 189–90  
 decision theory 186  
 decision trees 308–10, 446  
 declarative memory, information accessibility 223  
 deep learning 317–18, 446  
   application in autonomous vehicles 442–3  
   autoencoders 322–4  
   convolutional neural networks (ConvNets) 324–7  
   machinery of 321–7  
   visual cortex and 318–21

- deep reinforcement learning 327–30
- deep structure (phrase structure) of a sentence 26–8, 446
- default mode network (DMN) 439
- Dehaene, Stanislas 396–400
- delayed saccade tasks 248–9
- della Porta, Giambattista 182
- delta rule 450
- Dennett, Daniel 401
- deontic conditionals 211
- dichotic listening experiments 31–2, 446
- diffusion tractography 236
- digital information storage 50–1
- dimensionality reduction 322
- diminishing marginal utility 189
- dishabituation paradigm 286–92, 446
- distributed representations in neural networks 141, 446
- domain-general mental architecture, arguments against 214–18
- domain-specific mechanisms 446
- domains 128
- dopamine neurotransmitter activity 330
- dorsal visual pathway 70–6, 446
- double dissociation 385, 446
- Draine, Sean 392–3
- drawbridge experiments 287–8
- Duncan, John 242
- dynamic field model 163–5, 167
- dynamical modeling 150–3
- dynamical systems, definition 150–3
- dynamical systems approach
  - A-Not-B error 161–5
  - applications in child development 158–67
  - assessment of the approach 166–7
  - modeling motor control 159–61
- dynamical systems hypothesis 446
- dynamical systems theory 446
  - approach to cognitive science 149–58
  - basins of attraction in state space 157–8
  - relevance to cognitive science 153–8
- early selection model of attention 241–2, 446
- Ebbinghaus illusion 391
- EEG (electroencephalography) 446
  - brain mapping 237–41
- effective connectivity 446
- effector systems 204
- ELIZA program 39–40
- Elman, Jeff 266
- emergent behavior 427, 431–2
- entropy 446
- EPIC architecture 222
- epilepsy 439–40
- Evarts, Edward 190
- event-related fMRI 86–9, 447
- event-related magnetic fields 447
- event-related potentials (ERPs) 240, 447
- evolution of cooperation 213–15
- evolutionarily stable strategy 214
- exoskeletons (robot suits) 440
- expected utility 447
  - concept 189–90
  - neurons that code for 190–8
  - role of the lateral intraparietal (LIP) neurons 191–8
  - saccadic eye movement experiments 191–8
  - theory 187–90
- expected value 188–9
- expert systems
  - decision trees 308–10
  - machine learning and 308–15
  - research 447
- eyewitness testimony 441
- factive states 343
- false belief
  - implicit and explicit understanding of 347–8
  - Perner's model of theory of mind development 360–3
  - selection processor hypothesis 358–60
  - why it takes so long to understand 358–63
- false belief task 447
  - used to study mindreading 342–6
- false photograph task 369
- Fang, Fang 391
- feature engineering 316–17, 447
- feature learning 317 *see also* representation learning
- feedforward networks 137, 447
- Felleman, Daniel J. 234
- first-order predicate calculus 408
- fixed neural architectures 447
- flowchart model 28–9
- fMRI (functional magnetic resonance imaging) 240–1, 447
  - brain activity associated with remembering visual experiences 87–9
  - event-related 86–9
  - functional neuroimaging 84–7
  - see also* BOLD fMRI signal
- Fodor, Jerry 106–14, 207–10, 263–5, 301–2
- folk physics 288, 443, 447
- formal property 447
- fovea 447
- frame problem 447
- Frege, Gottlob 261
- Friston, Karl 91, 182–6
- Frith, Uta 342–6
- Frost, Douglas 386
- functional connectivity 447
- functional decomposition 447

- functional neuroimaging 447
  - with fMRI 84–7
  - with PET 81–4
- functional systems 447
- functional view of cognitive systems 66–8
- functions 128–30
- future challenges and opportunities 438–43
  - autonomous vehicles 442–3
  - brain connectivity 438–9
  - default mode network (DMN) 439
  - Human Connectome Project 438–9
  - law and cognitive science 441–2
  - neural prosthetics 440
  - what the brain is doing when it appears not to be doing anything 439
- Gahl, Susan 277–8
- General Problem Solver program 100, 105–6
- Gestalt school of perceptual psychology 180–1
- Glimcher, Paul 191–8
- global neuronal workspace theory 398–400
- global workspace theory of consciousness 396–400, 447
  - building blocks 396–7
  - versions 397–400
- goal-based agents 205–6
- Goel, Vinod 366
- GOFAI (good old-fashioned artificial intelligence) robotics 448
  - SHAKY robot 408–14, 416
- Goldberg, Michael 191
- Goldman, Alan 363–4
- Goodale, Melvyn, theory of vision 389–92
- Goodfellow, Ian 325
- Google
  - Deep Mind research program 317, 327–30
  - self-driving cars 442
- GoogLeNet 325
- Gopnik, Alison 292–3
- Gordon, Robert 365
- Gorman, Paul 78–80
- graceful degradation 448
- Greenwald, Anthony 392–3
- Griggs, Richard 212–13
- Haldane, John Scott 401
- Halligan, Peter 387
- halting problem 23–5, 448
- Hamilton, W. D. 217–18
- hard problem of consciousness 448
- Harris, Paul 363
- Haugeland, John 415
- He, Shen 391
- Heal, Jane 365
- Hebb, Donald 131–2
- Hebbian learning 131–2, 448
- Held, Richard 386
- hemiagnosia *see* unilateral spatial neglect
- hemineglect *see* unilateral spatial neglect
- Herrnstein, Richard 196
- heuristic strategies 105, 214, 448
- hidden layers 137, 448
- hidden units 77–8, 136, 448
- Hinton, Geoffrey 318, 320–1, 324
- hippocampal prosthetics 440
- hippocampus 7
- historical landmarks in cognitive science
  - approaches to understanding information 32–4
  - computation theory and the algorithm concept 22–5
  - information-processing models in psychology 28–32
  - interdisciplinary model of vision 53–61
  - language-processing systems and micro-worlds 38–47
  - linguistics and formal analysis of language 25–8
  - reaction against behaviorism 16–22
  - representation of mental images 47–53
  - turn to the brain 66–92
- Hohwy, Jakob 182–6
- Honzik, C. H. 17–20
- Human Connectome Project 438–9
- Human Genome Project 438
- hybrid architectures 219–24
- ID3 algorithm for machine learning 310–15
- ImageNet Large-Scale Visual Recognition Challenge 324–5
- imagery debate 47–53
- infant cognition
  - connectionist models 293–300
  - dishabituation paradigm and 286–92
  - interpretation of dishabituation experiments 292–3
  - modeling object permanence 295–7
  - modeling the balance beam problem 297–300
  - neural network models 293–300
  - traditional views 286
- infant folk physics, underlying information processing 292–3
- information, concepts of 32
- information channel 448
- information processing
  - approaches to understanding 32–4
  - artificial neural networks 78–80, 141–3
  - bottleneck 30
  - channel capacity 30
  - without conscious awareness 382–7
  - formal analysis of language 25–8
  - hierarchically organized behavior 21–2
  - how it works 33
  - human limitations 29–30

- learning without reinforcement 17–20
- mental imagery 50–3
- models in psychology 28–32
- neurally inspired models 124–8
- organization of the mind and 223–4
- reaction against behaviorism 16–22
- sensory information 30–2
- spatial learning studies 20–1
- specialized systems for 33–4
- information-processing systems, levels of
  - explanation 53–5
- information theory 28–9
- informational encapsulation 448
- innatism about language 262, 265
- insects, robotic studies 418–23
- integration challenge xxiv
- integration principle 237, 448
- intelligence, physical symbol system
  - hypothesis 100–6
- intelligent action, and the physical symbol
  - system 106
- intentional realism 108–10, 448
- intentionality 448
- interdisciplinary nature of cognitive science 3–5
- interocular suppression 448
- iSee 443
- isotropic property of central processing 210
  
- Jackson, Frank 380–1
- James, William 286
- Jasper, Herbert 190
- Jenkins, E. 298–9
- joint visual attention 351–2, 448
  
- Kanwisher, Nancy 368–9
- Kelly, William 374
- Kerszberg, Michel 398–400
- Keyser, Samuel Jay 5
- Kieras, David 222
- kin selection model 217–18
- Knowledge Argument 380–1, 448
- Koch, Christoph 91
- Koffka, Kurt 180
- Köhler, Wolfgang 180
- Kosslyn, Stephen 52–3
- Kuczaj, Stan 267
  
- language
  - natural language-processing systems 38–47
  - study of 25–8
- language learning
  - Bayesian language learning 274–80
  - challenge of tense learning 267–9
  - connectionist approach 266–74
  - connectionist models of tense learning 269–74
  - language of thought and 263–5
  - learning linguistic categories 278–80
  - neural network models 266–74
  - probabilities in word and phrase
    - segmentation 275–6
  - rules and language 260–2
  - understanding a language and learning a language 261–2
  - understanding pronouns 276–8
- language of thought hypothesis 106–14, 448
- language learning and 263–5
- main claims 110
- relation between syntax and semantics 110–14
- structure of the argument for 113–14
- language-processing systems
  - ELIZA program 39–40
  - SHRDLU program 40–7
- Lashley, Karl 21–2, 409
- late selection models of attention 242, 448
- latency 243
- latent learning 17–20
- lateral geniculate nucleus (LGN) 319
- lateral intraparietal area (LIP)
  - delayed saccade experiments 248–9
  - role of neurons in expected utility 192–8
- law, connections with cognitive science 441–2
- learning
  - without reinforcement 17–20
  - in single-layer networks 131–4
- learning agents 206–7
- learning algorithms 77–8, 140
- LeCun, Yann 318, 320–1
- Leibniz's Mill 448
- Leslie, Alan 342–6, 348
  - model of infant pretend play 336–7
  - on pretend play and metarepresentation 337–40
  - selection processor hypothesis 358–60
- levels of explanation 53–5
  - neuroscience and psychology compared 5–9
- lexical access 82, 449
- lexical decision task 383
- lexical processing, mapping the stages of 80–4
- Li, Fei-Fei 324
- Li, Kai 324
- Lidz, Jeffrey 277
- likelihood of the evidence 178–9, 449
- linearly separable functions 134–6, 449
- linguistics 25–8
  - role in cognitive science 3–5
- local algorithm 449
- local field potential (LFP) 92, 449
- local learning algorithms 140
- localist networks 141
- locus of selection problem 241–6, 449
- logic programming 408, 413–14
- Logic Theory Machine 100



- logical consequence 449
- logical deducibility 449
- Logothetis, Nikos 91–2
- Luria, Alexander 230–2
- Luzzatti, Claudio 385
- machine learning 449
  - algorithms 449
  - AlphaGo program 327–30
  - decision trees 308–10
  - deep learning 317–18
  - deep learning and the visual cortex 318–21
  - deep reinforcement learning 327–30
  - expert systems and 308–15
  - ID3 algorithm 310–15
  - machinery of deep learning 321–7
  - representation learning 315–17
- machine table 24
- Macrae, Neil 374
- macroeconomics 186
- magnetoencephalography *see* MEG
- mandatory application 449
- mapping functions 128–30
- Marchman, Victoria 272–3
- Marcus, Gary 273
- Marr, David 53–61, 300–1, 418
- Marshall, John 387
- masked priming 392–3, 449
- massive modularity hypothesis 210–19, 449
  - argument from error 216
  - argument from statistics and learning 216–18
  - arguments against domain-general mental architecture 214–18
  - cheater detection module 211–13
  - evaluating the arguments for 218–19
  - evolution of cooperation 213–15
  - evolution of mental architecture 216–18
  - kin selection model 217–18
- Matarić, Maja 428–32
- matching behavior 196
- mathematics, computation theory 22–5
- McClelland, Jay 269–72, 293, 298–9
- McCulloch, Warren 76, 128, 130
- means–end analysis 105–6
- MEG (magnetoencephalography) 449
  - brain mapping 240–1
- melioration theory 196–8
- Meltzoff, Andrew 292–3
- memory
  - brain activity associated with remembering visual experiences 87–9
  - visual event studies 84–7
- mental architecture 449
- mental imagery
  - how images are represented 47–53
  - information processing 50–3
- mental rotation of three-dimensional objects 48–50
- metarepresentation 341–8, 449
- metarepresentation, link to mindreading 341
- metarepresentation, pretend play and 337–40
- metarepresentation, why it takes so long to understand false belief 358–63
- Metzler, Jacqueline 47–50
- Meyer, David 222
- Michalski, Ryszard 314–15
- microcircuits 7–8
- microeconomics 186
- microelectrode recording of single neurons 90–2
- micro-worlds 40–7, 449
- Miller, George 5, 28–30
- Miller v. Alabama* (2012) 442
- Milner, David, theory of vision 389–92
- Milward, T. T. 140–1
- mindreading 443
  - autism and 341–2
  - cognitive neuroscience of 365
  - implicit and explicit understanding of false belief 347–8
  - Leslie's model of pretend play 336–40
  - link to pretend play 341
  - neuroscientific studies 365–75
  - pretend play and metarepresentation 336–41
  - role of co-opted mechanisms 369–75
  - role of simulation in high-level mindreading 373–5
  - role of simulation in low-level mindreading 369–73
  - significance of pretend play 336–7
  - using the false belief task to study 342–6
  - view of simulation theory 363–5
  - why it takes so long to understand false belief 358–63
- mindreading system 348–53
  - first steps in mindreading 349–51
  - from dyadic to triadic interactions 351–2
  - joint visual attention 351–2
  - theory of mind mechanism (TOMM) 352–69
- Minsky, Marvin 136
- mirror neurons 237, 371–3, 449
- Mishkin, Mortimer 70–6
- Mitchell, Jason 374
- MNI brain atlas 252
- modular cognitive processing 208–9
- modularity of mind (Fodor) 207–10
- modules 449
- Montague, Read 330
- Montgomery v. Louisiana* (2016) 442
- morphological computation 420–3, 449

- motor control
  - computational model 159
  - dynamical systems approach 159–61
  - robot hand (Yokoi) 421–3
- Mountcastle, Vernon 190–1
- multiagent programming, Nerd Herd robots 430–2
- multilayer networks 136–41, 450
  - backpropagation algorithm 138–9
  - feedforward networks 137
  - hidden layers 137
  - modifying the weights 138–9
  - spread of activation 137–8
- multiply realizable systems 67, 450
- Munakata, Yuko 293–7
- Musk, Elon 442
- MYCIN expert systems program 308
  
- Naccache, Lionel 396–7
- naïve physics 288
- nativism about language 262, 265
- natural language-processing systems 38–47
- neglect phenomenon 385 *see also* blindsight; unilateral spatial neglect
- Nerd Herd robots 430–2
- networks of attention 246–9
- neural correlates of the BOLD fMRI signal 90–2
- neural networks *see* artificial neural networks (connectionist networks)
- neural prosthetics 440
- neurally inspired models of information processing 124–8
- neuroeconomics 450
  - Bayes in the brain 186–98
- neuroimaging
  - functional connectivity versus effective connectivity 252–3
  - investigating the theory of mind system 366–9
  - techniques for studying cognitive functioning 237–41
- neurolaw 441–2
- neurological model of single-word processing 82–4
- neurons 7–9
  - activation functions 126–7
  - microelectrode recordings 90–2
  - structure and function 125–8
  - threshold for firing 125–6
- neurons that code for expected utility 190–8
  - combining probability and utility 196–8
  - probability-detecting neurons 193–4
  - utility-detecting neurons 194–5
- neurophilosophy 5
- neuroscience
  - branches of 7–9
  - compared with psychology 5–9
  - levels of organization 7–9
  - role in cognitive science 3–5
  - tools and techniques 9
- neurotransmitters 8–9, 450
- New Look perceptual psychology 180
- Newell, Allen 100–6
- Newport, Elissa 275–6
- Nicolelis, Miguel 440
- Nissl, Franz 232
- Nissl stain 232
- nonconscious information processing 382–7
  - blindsight and unilateral spatial neglect 384–7
- Norman, Donald 397
- NOT Boolean function 130–1
- numerals 109
  
- object permanence 450
  - development of 161–5
  - modeling approaches 293–5
  - network modeling 295–7
  - and physical reasoning in infancy 286–93
- object substitution 336
- Onishi, Kristine 347–8
- operant conditioning 450
- OR Boolean function 129–31
- organism–environment complex 156
- overregularization errors 268, 450
  
- P-consciousness (phenomenal consciousness) 393–4, 450
- paired deficits 370
- paired-image subtraction paradigm 450
- Papert, Seymour 135
- parallel distributed processing 77–8
- parallel processing 450
- paralysis, development of exoskeletons (robot suits) 440
- Parkinson's disease 439
- partial volume effects 251
- pattern recognition in artificial neural networks 78–80
- Pavlovian conditioning *see* classical/Pavlovian conditioning
- perception
  - as a Bayesian problem 179–86
  - binocular rivalry (Bayesianism case study) 182–6
  - predictive challenge 179–81
- perceptron 450
- perceptron convergence rule 131–4, 450
  - limits of 134–6
- Perner, Joseph 342, 360–3
- PET (positron emission tomography) 240–1, 450
  - cortical anatomy of single-word processing 81–4



- phenomenal consciousness (P-consciousness) 393–4, 450
- philosophy, role in cognitive science 3–5
- phrase segmentation 276
- phrase structure (deep structure) of a sentence 26–8
- phrase structure grammar 450
- physical symbol models, relationship to neural network models 300–2
- physical symbol system 450
- physical symbol system hypothesis 100–6, 142, 450
  - intelligent action and the physical symbol system 106
  - language learning and 263
  - language of thought 106–14
  - Russian Room argument 114–19
  - symbols and symbol systems 101–2
  - transforming symbol structures 102–6
- physicalism (materialism) 381
- Piaget, Jean 161–2, 286
- Pinker, Steven 268–9, 272
- Pitts, Walter 76, 128, 130
- place learning 19–21
- PLANEX software 413–14
- Platt, Michael 191–8
- Plunkett, Kim 272–3
- Polizzi, Pamela 359
- Pöppel, Ernst 386
- Population-Average, Landmark and Surface-Based (PALS) brain atlas 252
- position-invariant object recognition 140–1
- posterior probability 178–9, 183, 450
- poverty of the stimulus arguments 265, 450
- pragmatics of conversation 46–7, 450
- precentral gyrus 234
- predicate calculus 111–14, 451
- prestriate cortex 74, 451
- pretend play
  - autism and 341–2
  - Leslie's model 336–40
  - link to mindreading 341
  - metarepresentation and 336–41
  - significance of 336–7
- primary motor cortex 234
- primary somatosensory cortex 234
- primary visual cortex 7, 69–70, 234, 319, 451
- primary visual pathway 68–70
- priming 451
  - consciousness and 382–4
- Prince, Alan 268–9, 272
- prior probability 178–9, 451
- prisoner's dilemma game 214–15, 451
- probability calculus 173–4
- probability-detecting neurons 193–4, 196
- probability theory 187
- procedural memory 223
- procedures 42–6
- production rules 205, 222–4
- pronomial anaphora 276–8
- propositional attitudes 107–8, 360, 451
- propositional logic (propositional calculus) 101–2, 451
- psychology
  - compared with neuroscience 5–9
  - how it is organized 6–7
  - information-processing models 28–32
  - reaction against behaviorism 16–22
  - of reasoning 186
  - role in cognitive science 3–5
  - subfields and specializations 6–7
- psychophysics 31, 451
- Pylyshyn, Zenon 301–2
- Quine, Willard von Orman 210
- Quinean property of central processing 210
- Quinlan, Ross 310
- Raichle, Marcus 439
- range 128
- rats
  - learning in maze running 17–20
  - spatial learning studies 20–1
- recurrent networks 296–7, 451
- recursive definition 451
- reduction 451
- Rees, Geraint 91
- reflex agents 204–5
- Regier, Terry 277–8
- reinforcement, learning without 17–20
- reinforcement learning 451
- representation 21, 32–3, 107–8, 451
  - mental images 47–53
- representation learning 315–17, 451
- representational mind 362
- response learning 19–21
- retrograde amnesia 451
- reward prediction error hypothesis 330
- Rizzolatti, Giacomo 237, 371, 387
- robot reply (to the Chinese room argument) 452
- robotics
  - Allen robot 424–7
  - alternatives to GOF AI robotics 414–23
  - behavior-based robotics 427–32
  - biorobotics 418–23
  - challenge of building a situated agent 415–16
  - emergent behaviors 427, 431–2
  - GOF AI robotics 408–14, 416
  - hybrid architectures 427
  - insect studies 418–23
  - morphological computation 420–3
  - multiagent programming 430–2
  - Nerd Herd robots 430–2

- preconditions for intelligent problem solving 416–18
- robot cricket 419–20
- robot fish called WANDA 420–1
- robot hand (Yokoi) 421–3
- robots 204
- SHAKEY robot 408–14, 416
- situated cognition and knowledge representation 416–18
- situated cognition approach 415
- subsumption architectures 423–7
- TOTO robot 428–30
- Rock, Irving 180–1
- Roepstorff, Andreas 182–6
- Rolls, Edmund 140–1
- Rosenblatt, Frank 132–4
- Rumelhart, David 269–72, 293
- Russian room argument (Searle)
  - physical symbol system hypothesis and 114–19
  - responses to 117–19
  - Turing Test and 117
- saccadic eye movements 246, 452
  - experiments using 191–8
- Saffran, Jenny 275
- Sahraie, Arah 387
- Saxe, Rebecca 368–9
- scotoma 385
- search-spaces 103–6
- Searle, John 114–19, 315
- segregation principle 232, 452
- Sejnowski, Terrence 78–80, 330
- selection processor hypothesis 358–60, 452
- selective attention 31–2, 452
- selectivity/invariance problem 321
- self-driving cars 442–3
- self-reflection 374
- semantic priming 383–4, 452
- semantic property 452
- semantic system 41–2, 44–6
- sensory information processing 30–2
- sensory systems 204
- sentential logic 101–2
- SHAKEY robot 408–14
  - challenge of building a situated agent 416
  - software for logic programming in STRIPS and PLANEX 413–14
  - software for low-level activities and intermediate-level actions 409–13
- Shallice, Tim 397
- Shannon, Claude E. 28
- shared attention mechanism (SAM) 352
- shared weights 452
- Shepard, Roger 47–50
- Shepherd, Gordon 7–9
- shopping bots 204
- SHRDLU program 40–7, 415–16
- Siegler, Bob 298
- Simon, Herbert 100–6
- simple reflex agents 204–5
- simulation
  - role in high-level mindreading 373–5
  - role in low-level mindreading 369–73
- simulation theory
  - radical simulationism 365, 452
  - standard simulationism 363–4, 452
  - view of mindreading 363–5
- single-layer networks
  - Boolean functions 128–36
  - learning in 131–4
  - limits of perceptron convergence 134–6
  - linearly separable functions 134–6
  - perceptron convergence rule 131–4
- single-word processing, PET studies of cortical anatomy 81–4
- situated cognition 415, 452
  - knowledge representation 416–18
- Skinner, B. F. 17
- Skinner box 17
- Sloan Foundation's report (1978) 3–5
- Smith, Linda 159–61, 163–5
- solidity, principle of 451
- solidity constraint 290
- sonar target detection, artificial neural network 78–80
- space of cognitive science 10–11
- sparse connectivity 452
- spatial learning studies 20–1
- spatial neglect
  - nonconscious processing 384–7
  - what is missing 389
- spatial resolution 452
- spatial working memory 248–9
- spatially selective attention 246 *see also*
  - visuospatial attention
- Spelke, Elizabeth 288–93
- SSS hybrid architecture 427
- St. Petersburg game 188–9
- state space 150–3, 452
  - basins of attraction in 157–8
- stereotactic maps 251
- stimulus-onset asynchrony (SOA) 393
- stochastic gradient descent 329
- striate cortex 69–70 *see also* primary visual cortex
- STRIPS planner 413–14
- strong AI 118
- subconscious information processing
  - hypothesis 22
- subcortex 452
- subsumption architectures 423–7, 452
- subsymbolic representation 223–4
- superior colliculus 191

- supervised learning 132, 452
- SuperVision program 324–5
- surface structure of a sentence 26, 452
- Sylvian sulcus 230
- symbol-grounding problem 453
- symbol structures, transformation 102–6
- symbols and symbol systems 101–2
- synapses 8–9, 237, 453
- syntactic structures 26–8
- syntactic system 41–3
- syntax 25
- systems neuroscience 453
- systems reply (to the Chinese room argument) 453
- Talairach–Tournoux brain atlas 252
- task analysis hypothesis 22
- temporal resolution 453
- Tenenbaum, Joshua 278–80
- Tesla 442
- TESS (the empathizing system) 352–3
- Thelen, Esther 159–61, 163–5
- theory of mind mechanism (TOMM) 352–3, 453
  - development of 358–63
  - neuroimaging investigations 366–9
- Thompson, Susan 276
- threshold 453
- TIT FOR TAT strategy 214, 453
- Tolman, Edward 17–20
- Tooby, John 211, 213–14, 216–18
- top-down analysis, visual system 54–61
- TOTO robot 428–30
- Townsend, James T. 161
- tract tracing 234
- transformational grammar 26–8, 453
- transitional probabilities 275
- Trevethan, Ceri 387
- truth conditions 263–5, 453
- truth rules 263–5, 453
- truth table 129–30
- Turing, Alan 22–5, 106
- Turing machines 24–5, 101–2, 106, 453
- Turing Test, Russian Room argument 117
- two visual systems hypothesis 70–6
- Umiltà, Alessandra 373
- unconditioned stimulus 17
- Ungerleider, Leslie 70–6
- unified Theory of Cognition 10
- unilateral spatial neglect 76, 453
  - nonconscious processing 384–7
- universal Turing machine 106
- unsupervised learning 140, 453
- Urbach–Wiethe disease 370
- utility concept 189–90, 453
- utility-detecting neurons 194–6
- Van Essen, David 234, 252
- Van Gelder, Tim 153–6, 166
- ventral visual pathway 70–6, 453
- VisNet model 140–1
- visual cortex, deep learning and 318–21 *see also*
  - primary visual cortex
- visual experience, brain activity that predicts remembering 87–9
- visual perception, binocular rivalry (Bayesianism case study) 182–6
- visual system
  - dorsal and ventral pathways 70–6
  - interdisciplinary model 53–61
  - levels of explanation 53–5
  - Marr's model 53–61
  - position-invariant object recognition 140–1
  - top-down analysis 54–61
  - two visual systems hypothesis 70–6
  - vision for action and vision for perception 389–92
- visuospatial attention
  - hypotheses about how it works 248–9
  - networks of attention 246–9
- von Helmholtz, Hermann 180
- Walker, Edward 5
- WANDA (robot fish) 420–1
- Wason selection task 211–13, 453
- Watt, James 153–6
- Watt governor 153–6
- weak AI 118
- Webb, Barbara 419–20
- Weiskrantz, Larry 387
- well-formed formula 453
- Wertheimer, Max 180
- Wimmer, Heinz 342
- Winograd, Terry 40–7, 415–16
- Wittgenstein, Ludwig 262
- word segmentation 275
- Xu, Fei 278–80
- Yokoi, Hiroshi 421–3
- Zaitchik, Debbie 369