

Index

- Abstract entities, 29, 42
Acoustic behavior, during pursuit, 162
Acoustic images
formation of, in echolocation, 155–195
of targets, structure of, 185–192
Acoustic signal, and phonetic segment, 112–114
Acuity
grating, 146–148
stereo, 149–152
target-ranging, 170
vernier, 145–148
visual, 145–146
Alzheimer's disease
and olfactory cortex, 211
and olfactory deficit, 211
and perceptual motor skills, 206
Amiel-Tison, C., 118, 122
Amit, D. J., 95
Amnesia, characteristics of, 205
Animal(s)
as source of biological data, 119
study of, 12
Animal communication, principles of, 17
Animal models, 235
Anterior frontal lobe damage, 32–33
Anterior temporal cortex damage, 31–32
Anterograde amnesia, 205
Aplysia, synapse efficacy in, 87
Aplysia californica, 225–226
Arousal system, concurrent, 231
Assembly, Hebb's concept of, 84–85
Association-area cells, 84
Attempted perceptuomotor reconstitution, 27
Attention
definition of, 27
as spotlighting process, 49
Attention for action, 98
Auditory cortex, segregation of neural maps in, 192
Auditory processes, bat's use of, 158
Auditory systems, mammalian, 130–131
Bats, and use of echolocation, 157–195. *See also*
FM bats
Beecher, M. D., 124, 125
Bertoni, J., 118, 122
Between-category stimuli, 124
Bienenstock, E., 85
Binding
local or entity, 34
non-local or event; 35
problem of, 9, 29
Binding code
and convergence zone, 45, 49
as synaptic pattern of activity, 45
Binocularity, onset of, 149–151
Blomberg, M., 127
Blumstein, S. E., 128, 129
Bonding, problem of, 9
Brain
areas of, in eyelid conditioning, 220–222
chronological approach to study of, 11
as evolutive system, 4, 100
global view of functioning of, 15–16
as hardware construct, 73
as intentional engine, 101
levels of functioning of, 6
morphogenesis of, 76
ontogenetic history of, 6
phylogenetic history of, 6
states of vs. states of mind, 139–140
structure of, 6–8
as system of intertwined architectures, 73
Brain architecture
and cognitive processes, 83
main forms of, 76–77
Brain-computer metaphor, 83
Brain-damaged subjects, studies with, 128
Brain forms, developmental genetics of, 74–77
Brain structure, differences in, and learning, 218–219
Bridge locus neurons, and perception, 141
Bushy cells, 127–128

- Calcium, role of, 214–215
 Calpain, 214–215, 216
 Carlson, R., 127
 Categorical perception, 115–116
 in animals, 123–125
 Categorization
 development of, 117–118
 as problem, 131
 Cell loss, and adaptive plasticity, 234
 Cellular level, 67–68
 Cellular mechanisms, 221–222
 Cerebellum, as site for memory traces, 221
 Changeux, J.-P., 4, 16, 87, 93
 Chemistry of memory, 212
 Chemo-affinity hypothesis, 78
 Choke points, 35
 Chronicity, 13
 Churchland, Patricia, 2–3
 Circuit level, 68
 Circuits, memory, 203, 204–205
 Classical conditioning
 basic mechanisms of, 225
 eyeblink, 219–220
 forearm position, 222
 responses during, 220
 Coarticulation, 113
 Co-attention, 39
 Cochlear nucleus, subsystems of, 127–128
 Cognition
 analysis of, in rodent models, 209
 definition of, 5
 key brain areas in human, 205–206
 neuronal models of, 63–101
 rule-governed nature of, 14
 theories of, 11
 Cognitive architecture, classical model of, 57, 58
 Cognitive disorders, and memory, 203
 Cognitive (fact) learning, vulnerability of, 234–235
 Cognitive operations, neural architecture for, 27
 Cognitive science, and neuroscience, 64–65
 Color mixture, 143
 Concrete entities, 29
 representation of, 44
 Connectionism. *See* Parallel distributed processing
 Conscious perception, 141–142
 Consciousness
 content of, 28
 and self-consciousness, 54
 Constant-frequency (CF) sonar signals, 158
 Contextual complexity, 42
 and event binding, 35
 recording of, 27, 43
 Convergence
 of auditory temporal and spectral processes, 195
 process of, 185–194
 as storage requirement, 214
See also Forward convergence
 Convergence zone
 auto-interacting, 53
 and binding problem, 26
 computational techniques for, 28
 computational testing of, 56
 definition of, 39
 development of, 48
 operating principles for, 46–47
 orders of, 26
 placement of, 50–51
 structure and role of, 45–46
 types of, 47–48
 Co-occurrence, 45, 53–54
 Cortex, electrical stimulation of, 129
See also Frontal cortex; Neocortex; Prefrontal cortex
 Cortico-rubral synapses, 224–225
 Cotman, Carl W., 18, 201–235
 Crick, F., 30
 Cross-correlation function, 187–190, 195
 Cross-language studies, 117–118
 Damasio, Antonio, 15
 D'Arcy-Thompson, W., 74
 Darwinian scheme. *See* Variation-selection scheme
 Darwinian variations, 86
 Data memory, 212
 encoding of, by hippocampus, 211
 De Caspar, A. J., 122
 Declarative (factual) memory, 18, 202
 as distinct from procedural memory, 206
 Dehaene, Stanislas, 4, 16
 Delayed matching to sample (DMS) task, 207
 Delayed non-matching to sample (DNMS) task, 206–207, 208
 Dendrites, changes in morphology of, 216–217
 Diehl, R. L., 124
 Disparity, 151
 Dispositions, inherited (innate), 14–15
 Dissonance, 87

- DNA content, non-linearity of, with brain anatomy, 75
- DNA-encoded genetic program, 74
- Domain formation, 27, 43
- Dooling, R., 122
- Druss, B., 118
- Early learning**
- general comments on, 231–232
 - model systems for, 233
 - in olfactory system, 228–229
 - structural correlates of, 229
 - as survival medium, 228
- Echo(es), arrival time of, and range profile, 185
- Echo components, in two-glint waveforms, 175–178
- Echo delay**
- bat's use of, 166
 - perceptual acuity for, 167–170
- Echo-delay jitter technique, 169–170
- Echo jitter procedure, 185–187, 189–190
- Echolocation, 17–18
- as biological sonar system, 156
 - FM signals for, 194
 - formation of acoustic images in, 155–195
 - operating range of, 163–165
 - and perception of target range, 157–170
- Echo spectra
- and cross-correlation function, 193–194
 - notches in, and target shape, 180
 - and shape discrimination, 184
 - transformation of, into time delays, 183–185
- Echo variability, and target discrimination, 172
- Edelman, G. M., 4, 131
- Elenius, K., 127
- Eliminative materialism, 2–3
- Elman, J. L., 131
- Engram, 219
- search for, 18
- Entities, 29
- definition of, 42
 - See also* Abstract entities; Concrete entities; External entities; Internal entities; Non-language entities
- Environment
- and cortex, 216–217, 234
 - and neuron structure, 216–217
- Enzymes, catalytic activity of, 66–67
- Epigenesis, and preformation, 74
- Events**
- definition of, 42
 - and entities, 29
 - kinds of, 42
- Explanations, knowledge-based vs. mechanism-based, 70
- External entities, 44
- Eyeblink, classical conditioning of, 219–220
- Eyelid conditioning, 219–222
- Fact memory**, 202
- Feature-based fragments, 45
- Feedback**
- and feed-forward, 57
 - vs. re-entry, 57
- Feldman, J. A., 203
- Firing**
- origin of, 89
 - spontaneous, 86
- FM bats
- perception of target shapes by, 170–185
 - sonar sounds of, 178
 - spectral representation of target structure to, 174–180
- Fodor, J. A., 2, 57, 97, 99, 100
- Forearm position, classical conditioning of, 222–224
- Forgetting, origin of, 90–91
- Form, perception of, 5
- Formalism, 85, 89
- need for, 13
- Forward convergence, and retrodivergence, 37–38
- Fragments, 34
- Frequency-modulated (FM) sonar signals, 158
- Frontal cortex, and development of cognition, 71
- Frontal lobe, genomic evolution of, 76
- Functional organization, multiple levels of, 67–71
- Functional regionalization, 43–44
- Functions, characteristics of, 71
- Generic knowledge, 34
- Genetic envelope, 78–79
- Geschwind, N., 30
- Glint(s), 195
- definition of, 174
 - distribution of, and range profile, 174
- Gottlieb, G., 122
- Gould, J., 122
- Grandmother cells. *See* Pontifical cells

- Granstrom, B., 127
 Grating, process of, 17
 Grating acuity, 146–148
 Green, S., 120
 Greenough, W. T., 217
 Griffith, B. C., 115
- Habituation, 225
 Halsted, N., 118, 122
 Harris, K. S., 115
 Head-aim tracking accuracy, bat's, 159
 Head-movement artifact, 166
 Hebb, D. O., 53, 86
 Hebbian assemblies, and representations, 83–85
 Hebb synapse, and resonance, 87–88
 Heidmann, T., 87, 93
 Held, Richard, 17
 Henri algorithm, 66
Hermissenda, 226–227
 Hippocampus
 and data memory, 211
 and LTP, 213–215
 and memory, 204–205
 Hirsh-Pasek, K., 118
 Hoffman, H. S., 115
 Homeostat, 83–84
 Hopfield, J., 85, 88
 Hopfield model, 90
 Hubel, D., 144
 Hyperbolic frequency scale, 194, 195
- Image(s)
 fusion of time- and frequency-domain information into, 192–194
 and neural representations, 156
 neural substrate of formation of, 192
 Imagery, and perception, 142
 Ingvar, D. H., 129
 Insects, sonar interception of, 158–165
 Intentment, 69
 and knowledge, 70–71
 Intention(s)
 and frontal cortex, 96–97
 and inventions, 96
 neural base for, 97
 selectionist test for, 97–98
 Intentionality, and context dependence, 97
 Interception, stages in, 159
 Internal entities, 42
- Internal organization, genesis of, 96
 Invariance problem, 112, 113–114
 Inventions, selectionist test for, 97–98
 Invertebrates, as research tool, 225–227
 Isomorphism, lack of, 112
- Jitter, effect of, 168
 Julesz, Bela, 45
 Jusczyk, Peter W., 16–17, 117, 118
- Kandel, E. R., 12, 226
 Kant, I., 69
 Katz, J., 117
 Kemler Nelson, D. G., 118
 Kennedy, L., 118
 Key brain regions, and memory, 203
 Killeen, P. R., 124
 Kluender, K. R., 124
 Knowledge
 at categoric levels, 34
 entity-centered, 52–53
 requirement for episodic, 34
 Konishi, M., 131
 Kosslyn, S. M., 13
 Kuhl, P. K., 117, 123, 124
- Labilization, 79
 Lamarckian associationism, 100
 Lamarckian mechanism, 85
 Lambertz, G., 118, 122
 Language
 innate vs. acquired, 55
 neurobiological understanding of, 5
 Larson, J. R., 217
 Lassen, N. A., 129
 Learning
 in *Aplysia californica*, 225–226
 in cortical circuitries, 228
 definition of, 202
 and differences in brain structure, 218–219
 in *Hermissenda*, 226–227
 in *Limax*, 227
 and LTP, 215–216
 and memory, 51–54
 neural substrates for, 53–54
 neurobiology of, 201–235
 sequence of, 235
 synaptic mechanism of, 224
 See also Early learning

- Learning signals, 212
- Lesion method, 55–56
human studies with, 30–38
- Levels of analysis, algorithmic (computational), 3–4
- Levels of organization
in biological systems, 65–67
transition between, 71–73
- Lhermitte, F., 71
- Liberman, A. M., 114, 115, 130
- Limax*, 90, 227
- Linking propositions, 140
- Lisker, L., 113
- Little, W. A., 85
- Livingstone, M., 144
- Long-term memory
molecular mechanism for, 93
organization of, 92–93
- Long-term potentiation (LTP), 235
causes and substrates of, 214–215
characteristics of, 213–214
and learning, 215–216
as learning component, 213
- LTP. *See* Long-term potentiation
- Luria, A. R., 30
- Lynch, Gary S., 18, 201–235
- Mann, V. A., 114
- Marler, P., 122
- Matching-to-sample procedures, 235
- McClelland, J. L., 131
- McCulloch, W. S., 14, 88
- Mealworms, vs. disk, 172–174
- Medial temporal lobe region
and declarative memory, 206
and memory formation, 205
- Mehler, J., 118, 122
- Memory
in *Aplysia californica*, 225–226
categories of, 202
distinction in kinds of, 18
in *Hermissenda*, 226–227
and learning, 51–54
in *Limax*, 227
neural substrates for, 53–54
neurobiology of, 201–235
- Memory-blocking, 213
- Memory circuits, 203
definition of, 205–206
- Memory deficit
and hippocampal lesion, 208
primates vs. man, 206–209
- Memory domains, relative segregation of, 51–52
- Memory processing, levels of, 52
- Memory storage, brain's capacity for, 204
- Memory systems, anatomically distinct, 208
- Memory trace, in eyelid conditioning, 219–222
- Mental atomism, 74
- Mental Darwinism, 85–87
- Mental objects
and mental Darwinism, 83–90
modeling of, by statistical physics, 88–90
- Mental representations, 89
neural implementation of, 99
and variation-selection terms, 85–86
- Mental states, Darwinian selection of, 89
- Meta-circuit level, 68–69
- Michaelis-Menten algorithm, 66, 67
- Mid-diencephalic structure, 206
- Miller, J. D., 123
- Miller, Joanne L., 16–17, 116
- Mind
chronological approach to study of, 11
concept of, as diminishing, 141
structure of, 5
- Mind-body problem, 2–3
- Mind-brain correspondence, 8–9
- Models of the brain* (Young), 83
- Monod, Jacques, 66
- Moody, D. B., 124, 125
- Morphological archetypes, theory of, 74
- Morse, P. A., 124
- Natural selection, 4
- Neocortex, 204
- Neural architecture
assumptions for, 94
and cognitive science, 90–98
- Neural form, ontogenesis of, 73–77
- Neural maps
overlap of, 193
segregation of, 192–193
- Neural phenotype, 78
- Neural structures, adult-neonatal, 232
- Neuroethological approach, 156–157
- Neurological injuries, studies of, 18
- Neuron(s)
size of population of, 84–85

- Neuron(s) (*cont.*)
 structure of, and environment, 216–217
 types of, 7
- Neuronal group selection theory, 15, 58
- Neuronal networks
 epigenesis of, 77–83
 short-term memory of, 90–92
- Nervous system
 development of, 72–73, 233–234
 information processing scheme of, 79
 maturation of, 234
 and perception, 152
- Newell, A., 69, 70
- Newton, Isaac, 143
- N-methyl-D-aspartate (NMDA) receptor, 214, 216
 critical role of, 229
- Non-associative learning, 225
- Non-language entities, 55
- Object discrimination task, 207, 208
- Ojemann, G., 129
- Olfaction, 209
- Olfactory cortex
 and Alzheimer's disease, 211
 and memory-related brain structures, 209–210
- Olfactory deficits, 210–211
- Olfactory memory, 211–212
- Olfactory system, 228–229
- Ontogenesis, and changes in morphology of brain, 7–8
- Ontogeny, 5
- Organization of behavior, The* (Hebbs), 16, 84
- Padden, D. M., 124
- Parallel distributed processing, 57, 58
- Paths of transmission, 144
- Penfield, W., 30, 129
- Perception
 categorical, 115–116, 123–125
 featural fragmentation of, 29
 Held's view of, 17
 intuitively reasonable view of, 29–30
 link of with production, 121–122
 mechanisms of, 130
 and production, 129
 and recall, 44
 as reflective activity, 139
 and sensorineural substrate, 140–144
See also Speech perception
- Perceptual impairments, 33
- Perceptual motor skills, in impaired patients, 205–206
- Perceptual systems, non-human, 131
- Peters, S., 122
- Petersen, M., 120
- Phonetic segment, and acoustic signal, 112–114
- Phonetic structure, 114–116
- Phylogeny, 5
- Physical change
 and changes in functional capacities, 12
 and observed behavior, 9–12
- Physiological codes, 11
- Pisoni, D. B., 115
- Pitts, W. A., 14, 88
- Place of articulation, 128
 human vs. animal, 124–125
- Plasticity
 adaptive, 234
 damage-induced, 222, 225
 mechanisms for, 212–219
- Pontifical cells, 84
- Positive feedback loop, 93
- Positron emission tomography, 56
- Posner, M. I., 13
- Predisposition, need for, 14
- Preformation, and epigenesis, 74
- Prefrontal cortex
 functions of, 97
 role of, in delayed-response tasks, 100
- Prelinguistic infants, 116–118
- Pre-representations, 86–87
 criteria for selection of, 100
- Primacy effect, 91
- Procedural learning, memory circuits in, 219–227
- Procedural (rule) memory, 18, 202
 vs. declarative memory, 234
- Processing streams, 40
- Production, and perception, 121–122, 129
- Protein synthesis, 226
- Psychophysics, 140
- Pugh, E. N., Jr., 140, 141
- Pursuit maneuver, 162–163
- Pylyshyn, Z. W., 57, 70, 97, 99, 100
- Range-profile thresholds, 180
- Rate-place models, 125
 limitations of, 126
- Reason, and intendment, 69

- Recall
 impairments in, 33
 neural substrates of, 25–28
 and perception, 44
- Red nucleus
 common mechanism for, 234
 and conditioning of limb position, 222–224
- Regionalization, 27
- Regression, 79
- Remanence, 95
- Repp, B. H., 114
- Representation
 components of, 45
 and Hebbian assemblies, 83–85
 meanings of, 84
 nature of, 44
- Resonance, 87
- Response latency patterns, 125
- Retroactivation
 meaning of, 26
 time-locked multiregional, 25–58
- Rhodopsin, 143
- Right ear advantage, 121
 for stop consonants, 128
- Rostral integration, 38
- Rule memory, 202
- Rules, neural representation of, 99
- Schmitt, Frank, 1
- Searcy, M. A., 122
- Segmental perception, 130
- Segmentation problem, 112–113
- Segregation
 and integration, 36
 neural activity as requirement for, 230
- Semantic knowledge, 34
- Sensation, and stimulation, 140
- Sensitization, 225–226
- Sensory intervention, 121
- SEs, 120
- Shallice, T., 71
- Short-term memory, 92
- Simmons, James, 17–18
- Simon, H. A., 69, 91
- Single-modality cortices, 33–35
- Sinnott, J. M., 124, 125
- Skill memory, 202
- Skinhoj, E., 129
- SLs, 120
- Snowden, C. T., 124
- Soli, S. D., 113
- Somatic states, 57
- Sonar
 interception of, insects by, 158–165
 spatial perception through, 159
- Song-specific neurons, 94
- Space
 entity-extrinsic, 42
 entity-intrinsic, 42
- Species-specific calls, 119–123
- Spectral cues, 178
- Spectrograms, 160
- Speech perception, 16
 by animals, 123–125
 characteristics of, 112–118
 developmental course of, 116–118
 and innately guided learning, 122–123
 motor theory of, 114
 neurobiological bases of, 111–131
 neurophysiological bases for, 118–130
- Speech processing
 in central auditory system, 127–130
 cerebral specialization for, 119
 in peripheral auditory system, 125–127
- Spence, M. J., 122
- Spin glass formalism, 89
- Spontaneous activity, prenatal, 79, 82
- Stabilization, 79
- Standing, L., 203
- Stebbins, W. C., 124, 125
- Stellate cells, 127–128
- Stereoacluity, 17, 146, 149–152
 definition of, 151
- Stereopsis, 149
- Symmetry breakings, 75–76
- Synapse(s), 7
 active selection of, 77–83
 chemical composition of, 212–213
 environmental influences on, 216
 model for, 79–81
 states of, 79
- Synapse turnover, 18, 217–218
- Synaptic connections, 76
- Synaptic mechanisms, 203
- Synaptic transmission, 225–226
 and protein synthesis, 226
- Target(s)
 acoustic images of complex, 180–183
 discrimination of airborne, 171–174
 structure of acoustic image of, 185–192

- Target identification, basis for, 171
 Target range
 acuity of perception of, 166–170
 bat's perception of, 181–183
 definition of, 156
 and FM echo delay, 194
 Target-range discrimination experiment, 166
 Target ranging acuity, 170
 Target shape, perception of by FM bats, 170–185
 Target simulator, 167
 Target structure, spectral representation of, 174–180
 Tash, J., 115
 Tees, R. C., 117–118
 Teller, D. Y., 140, 141
 Teller's Analogy proposition, 143
 Temporal pattern models, 126
 obstacles to, 126–127
 types of, 126
 Temporal sequence networks, 94–96
 Temporo-spatial integration, 28–30
 Textons, 45
 Third ventricle region, and memory formation, 205
 See also Mid-diencephalic structure
 Thom, R., 74
 Threshold curves, 180
 Time delay, and echo spectra, 183–185
 Time-locked activations, 56
 Time-locked multiregional retroactivation
 and domain formation, 43
 framework of, 40–41
 and functional regionalization, 43–44
 and reality constraints, 41–42
 and recording of contextual complexity, 43
 Time-scales, 100
 Time sequences, 93–96
 Tonotopic map, 192
 Toulouse, G., 89
 Transformations, theory of, 76
Tritonia, 90
 Tsukahara, N., 222, 224
 Turing, A. M., 75
 Uniqueness, mapping of, 52–53
 Unitary perception, from disparate neural representations, 157–158
 Variability
 sources of, 78–79
 theorem of, 81–83
 Variation-selection scheme, 71–73
 Vernier acuity, 17, 145–148
 Visual acuity, 145–146
 Visual capacities, development of, 144–152
 Visual cortex organization, 230–231
 Visual system
 development of, 230
 requirements for, 230, 233–234
 Vocalizations
 maternal, 122
 primate, 119–121
 Voice-onset time (VOT), 115–116
 in animals, 123–124
 Voicing contrasts, 129
 Volaitis, L. E., 116
 Von der Malsburg, C., 85
 VOT. *See* Voice-onset time
 VOT boundary, 124
 Werker, J. F., 117–118
 Wernicke's area, 129
 Withers, G. S., 217
 Within-category information, 115–116
 Wright, K., 118
 Yeni-Komshian, G. H., 113
 Young, E. D., 127
 Young, J. Z., 83
 Young, Thomas, 143
 Zoloth, S., 120