

INDEX

A

Accent training, 174
 AC (anterior cingulate) cortex
 in detection of changes in sensory events, 494
 in spatial concordance, 492
 Acoustic transfer function, of vocal tract, 206
 Acquisition, in odor-taste learning, 75–76
 Action(s)
 as binding key to multisensory integration, 425–439
 and perception, 425
 potential, 431
 in space, circuit for, 426–432
 Action observation-execution matching system, 436
 Action understanding
 circuit for, 434–438, 455
 hypotheses of, 454
 Activation interaction designs, for hemodynamic studies, 497–498
 Active intermodal mapping (AIM)
 hypothesis, and speech perception, 190, 196
 Active manipulation, in object recognition, 129, 132
 Active touch, in object recognition, 128–129
 ADAN (anterior directing attention negativity), 559, 560
 Additive model, for event-related potentials, 504–505
 AEPs (auditory evoked potentials)
 age of cochlear implantation and, 763
 in rat cortex, 361–363, 365
 AES. *See* Anterior ectosylvian sulcus (AES)
 AEV. *See* Anterior ectosylvian visual area (AEV)
 Affect
 multisensory attributes of, 652
 multisensory perception of, 581–594, 593
 attention in, 584–585
 conscious *vs.* nonconscious, 590–593
 electrophysiological studies of, 585–587
 in faces and voices, 582–584
 neuroanatomy of, 586–589
 selective pairing mechanism in, 589–591
 time course of, 585–587
 Affective value, of stimuli, neuroimaging studies of orbitofrontal cortex and amygdala in, 563–572
 African robin chat, multisensory signals in, 226
 Aggressive behavior, multisensory signals in, 229, 230–231

AIM (active intermodal mapping)
 hypothesis, and speech perception, 190, 196
 AIP (anterior intraparietal area)
 connections to, 289
 in movement planning, 464–465
 Alarm behavior, multisensory signals in, 230
 Alliesthesia, 72
 Alphanumeric synesthesia, and multisensory processing, 847–848
Alpheus heterochaelis, multisensory signals in, 234
 American Sign Language (ASL), cerebral organization of language with, 731, 740
 Amnesia, dense, 337, 338–339
 Amodal invariance
 perception of
 in early development, 660, 663, 671
 effect of modality-specific cues on, 661–662
 of temporal synchrony, 644, 664–665
 Amodal perception view, 652
 Amodal stimulus properties
 defined, 660
 examples of, 644
 intersensory redundancy for perceptual learning about, 648–649
 perception by infants of, 644
 salience during early development of, 645–646
 specification of multisensory object or event by, 660
 Amygdala
 activation by aversive and pleasant tastes of, 567
 and auditory reinforcers, 572
 in cross-modal learning, 334, 336–337, 338
 in emotion
 audiovisual perception of, 586, 588
 cross-modal integration of auditory and visual, 572
 neuroimaging studies of, 563–576
 imaging methods for, 564
 multisensory convergence in, 311, 321
 in representing affective value of stimuli, 564–572
 gustatory, 567
 olfactory, 568
 in responses to visual reinforcers, 571–572
 stimulus-reinforcer learning in, 563–564, 573–576
 Anatomical plasticity, 721–722
 Ancillary geniculate nucleus, in auditory speech pathway, 212

Angular gyrus, in synesthesia, 875, 877
 Animals
 multisensory communication in, 225–236
 descriptive observations of, 226–227
 multisensory perception in, 38
 multisensory processes in
 for attention and perception, 235
 for development and learning, 233–235
 function and evolutionary history of, 235–236
 multisensory signals in, 225, 226
 classification of, 227–228
 composite, 227, 228
 cues *vs.*, 227
 dominance of, 232–233
 emergence of, 234
 enhanced responses to, 229–230
 equivalence of, 229
 independence of, 232
 modulation of, 233–234
 nonredundant, 227–228, 230–234
 redundant, 227–230
 Anosmia, 73
 Ant(s), multisensory signals in, 227, 230
 Anterior cingulate (AC) cortex
 in detection of changes in sensory events, 494
 in spatial concordance, 492
 Anterior directing attention negativity (ADAN), 559, 560
 Anterior ectosylvian sulcus (AES)
 external afferents to, 344–345, 348
 correspondence to functional representations of, 345–348, 349, 350
 higher-order, modality-specific cortical representations in, 343–344
 intrinsic cross-modal connectivity of, 349–351
 in multisensory integration, 254–255, 256, 484
 in superior colliculus, 634–637, 638
 multisensory neurons in, 347–352
 in normal and visually deprived cats, 696–697
 sensory response pattern of neurons in, 345–348
 in superior colliculus-mediated orientation behavior, 257–259
 Anterior ectosylvian visual area (AEV), 254
 cross-modal connectivity of, 349–351, 352
 location of, 343
 projections to, 345, 870, 872
 sensitivities of, 344

- Anterior intraparietal area (AIP)
connections to, 289
in movement planning, 464–465
- Anticipation errors, 396
- Anticipatory slow potentials, 505
- Aphaenogaster*, multisensory signals
in, 230
- Aphasia, sign language, 777–778
- Apis mellifera*, multisensory signals
in, 229
- Apparent motion
across audition, touch, and
vision, 60–62
in different modalities, 50–52, 54–57
influence of static events on perception
of, 49–50, 52
modality dominance with, 62–64
- Arm movement control, in rotating
environments, 414–417
- Artists, synesthesia in, 876–877
- ASL (American Sign Language), cerebral
organization of language
with, 731, 740
- Association, in audiovisual integration,
204, 216–218
- Association cortex, input to superior
colliculus from, 254, 255–257
- Associative learning
in animals, 234
audiovisual
hemodynamic studies of, 495
magnetoencephalography
of, 520–522
in multisensory integration, 328
- Associative learning procedures,
potentiation in, 673
- Associative learning theory, in odor-taste
learning, 78, 79
- Associators, in synesthesia, 837, 839–841,
847, 861, 862
- Astatotilapia strigigena*, multisensory
signals in, 229
- Attention
allocation of, 144–145
in animals, 235
in audiovisual emotion perception,
584–585
covert shifts of, 3, 4
in cross-modal dynamic capture, 63
in cross-modal reorganization, 698
electrophysiological studies of,
549–561
multisensory convergence in,
326–328
and qualia, 879
selective
to amodal stimulus properties during
early development, 645–646
in color-graphemic synesthesia,
856–861
congruence effect in, 87–89
with cross-modal stimulation, 85–103
Garner interference in, 87
separable *vs.* integral dimensions
in, 86–87
speeded classification for study
of, 85–86
spatial. *See* Spatial attention
and target stimulus, 279
in ventriloquism effect, 144–145
- Attentional control systems,
supramodal, 546
- Attentional interactions, cross-modal,
functional imaging evidence for,
529–546
- Attentional load, in color-graphemic
synesthesia, 856–861
- Audiogravic illusion, 412
- Auditactile integration,
magnetoencephalography
of, 518–519
- Audiovisual associative learning,
magnetoencephalography
of, 520–522
- Audiovisual convergence, in early cortical
processing, 295–307
evidence of, 296–297
feedback, 299–303
feed-forward, 298–303
koniocellular input in, 303
mechanisms of, 298–303
sensory hierarchy for, 306–307
temporal parameters of, 295–296,
303–306
- Audiovisual convergence zones,
483, 484
- Audiovisual-evoked potentials (AVEPs),
362, 364, 366–367
- Audiovisual illusion, 663
- Audiovisual integration
after cochlear implantation
discussion of, 761–767
in postlingually deaf adults, 752–754
in prelingually deaf children,
754–761
convergence *vs.* association in, 204,
215–218
defined, 204
magnetoencephalography of, 518
multiple electrophysiological
mechanisms of, 503–511
multiplicity and flexibility of neural
mechanisms for, 509–510
task dependency of, 510
- Audiovisual interactions
hemodynamic studies of, 483–499
activation interaction designs for,
497–498
approaches to, 484–485
background for, 483–484
deactivation interaction designs for,
498–499
for detection of changes in sensory
events, 494
human imaging studies of,
485–496
for integration at semantic level,
488–490
for integration of phonetic
information, 486–488
intersection and conjunction designs
for, 496–497
linguistic, 485–490
nonlinguistic, 491–494
in pathological states, 495–496
in priming studies, 490
relating to associative learning, 495
relating to emotion, 494–495
for spatial concordance, 491–494
for temporal correspondence, 491
during speech perception, 530
- Audiovisual mirror neurons
in circuit for action understanding,
434–435
in speech perception, 215
- Audiovisual multisensory zone (MZav),
362, 364, 367
- Audiovisual perception, of emotion,
581–582
attention in, 584–585
conscious *vs.* nonconscious,
590–593
electrophysiological studies of,
585–586, 587
in faces and voices, 582–584
models for, 593
neuroanatomy of, 586–589
selective pairing mechanism in,
589–591
time course of, 585–587
- Audiovisual priming studies, 490
- Audiovisual properties, of speech and
spoken language, 765–767
- Audiovisual speech
conditions for, 178–179
production-based animation in,
185–186
response to, 668–670
- Audiovisual speech binding, 203–219
defined, 204
- Audiovisual speech integration,
hemodynamic studies of,
485–490
- Audiovisual speech perception
after cochlear implantation, 749–768
discussion of, 761–767
duration of deafness and, 754–755,
758, 760, 762–763, 766–767
lipreading skills and, 765–766
with oral communication *vs.* total
communication, 755, 757–758,
763–765
in postlingually deaf adults, 752–754
predictors of success with, 761
in prelingually deaf children,
754–761
sources of variation in, 754–755,
764–765
common format, 204–207
neural implementation of,
215–216
direct-realist theory of, 190, 197–198,
206, 215
eye movements and gaze location
in, 182

- feature integration information-processing theories of, 215–216
 - image characteristics in, 179–184
 - lipreading cues in, 749–750
 - McGurk effect in, 177, 205, 207–208, 750
 - mirror neurons in, 215
 - modality-specific, 207–210
 - neural implementation of, 216–218
 - neural implementation of, 210–215
 - auditory speech pathway in, 211–213
 - common format, 215–216
 - modality-specific, 216–218
 - multisensory input to cortex from brainstem in, 214
 - temporal constraints in, 214–215
 - testing theories of, 218
 - visual speech pathway in, 213–214
 - primary modality in, 751–752, 766
 - proposed mechanisms of, 750
 - reasons to study, 750
 - spatial and temporal constraints on, 177–186
 - spatial resolution in, 179–181
 - synchrony in, 183–184
 - visual resolution in, 181–182
 - Audiovisual speech perception
 - effects, 203
 - common format theory of, 205
 - theories to account for, 203
 - Audiovisual speech production, 184–185
 - Audiovisual speech stimulus
 - correspondence, modeling of, 209–210
 - Audiovisual stimulus, spatial position of, 731
 - Audiovisual synchrony, 183–184
 - Audition, cross-modal dynamic
 - capture across touch, vision, and, 60–64
 - Auditory apparent motion, 50–52, 54–57
 - Auditory behavior, in visually deprived mammals and blind humans, 695–696
 - Auditory belt cortex, in auditory speech pathway, 211
 - Auditory belt neurons, 212
 - Auditory “capture,” of visual structure, 28–29
 - Auditory consequences, of altered visual experience, 604–606
 - Auditory cortex
 - activation by visual stimuli of, 778–779
 - activation in deaf subjects of, 124
 - in auditory speech pathway, 211
 - connections of visual cortex with, 285–287
 - evoked potential mapping of, 360–364
 - in lipreading, 31
 - multisensory convergence in, 297–298, 302–303, 305
 - in sound localization, 696
 - in speech-reading, 774–775, 776
 - vibrotactile activation of, 777
 - visual networks in, 685–688
 - visual responsiveness in, 659
 - Auditory dominance, 662
 - cross-modal interactions with, 507, 508, 510
 - Auditory edges, 125
 - Auditory emotion, cross-modal
 - integration of visual and, 572
 - Auditory-evoked potentials (AEPs)
 - age of cochlear implantation and, 763
 - in rat cortex, 361–363, 365
 - Auditory input, encoding of, 377
 - Auditory koniocortex (KA), in auditory speech pathway, 211
 - Auditory localization, 37. (*see also* Auditory space map)
 - with blindness, 731–735
 - errors in, 411–412
 - Auditory localization cues, 613
 - Auditory map, aligning visual and, in ferret midbrain, 599–610
 - Auditory-on-visual cuing, 7
 - Auditory parabelt region, connections to visual cortex of, 286–287
 - Auditory pathway, routing visual inputs to, 683–685
 - Auditory perception, with blindness, 723–725
 - Auditory peripersonal space, auditory-tactile interactions in, 809–810
 - Auditory processing, 212
 - cross-modal links with
 - in endogenous spatial attention, 550–552, 554, 559–561
 - in exogenous spatial attention, 557
 - in musicians, 724
 - Auditory reference frames, 463
 - Auditory reinforcers, amygdala and, 572
 - Auditory response(s), visual signals in
 - shaping of, 605–607
 - Auditory response properties, in superior colliculus, maturation of, 627–628
 - Auditory scene analysis, 147
 - Auditory selective adaptation effect, 207
 - Auditory/somatosensory-evoked potential (ASEP) mapping, 362, 363–365, 366–367, 368
 - Auditory/somatosensory multisensory zone (MZas), 362–366, 367–368
 - Auditory space map, 613, 614
 - alignment of visual and, 621
 - effect of partial occlusion of visual field on, 617, 618
 - initial formation of, 620
 - innate aspects of, 614
 - instructive signal for, 617–620
 - effect of partial occlusion of visual field on, 617, 618
 - gating of, 618–619
 - maintenance role of, 619–620
 - nature and mechanisms of, 620–621
 - source of, 617–618, 619
 - model of adaptive plasticity for, 620–622
 - in owls, 731
 - site of plasticity for, 616
 - visual calibration of, 614–616
 - visual instruction of, 613–623
 - Auditory space processing
 - calibration signals for, 697–698
 - in superior colliculus, plasticity of, 604–606
 - Auditory spatial representations, visual cues in, 731–734
 - Auditory speech pathway, 211–213
 - Auditory stimuli
 - activation of orbitofrontal cortex by, 572
 - eye-centered representations of, in posterior parietal cortex, 473–475
 - Auditory-tactile integration, 111–112, 115–116
 - Auditory-tactile interactions, in near auditory space, 809–810
 - Auditory-target location, in eye-centered reference frame, 467, 468
 - Auditory thalamus, visual responsiveness in, 659
 - Auditory-verbal therapy, 755
 - Auditory-visual integration, in complex environments, 386–388, 390
 - Auditory-visual interactions
 - subserving primate gaze orienting, 373–391
 - visual neglect as probe for investigating, 810
 - Auditory-visual modulation, of neglect, 811–812
 - Auditory-visual stimuli, eye-head
 - coordination to, 382–383, 389
 - Auditory-visual synesthesia, 93
 - Autistic children, teaching new vocabulary to, 174
 - AV. *See* Audiovisual
 - AVEPs (audiovisual-evoked potentials), 362, 364, 366–367
 - Average rectified current flow (AVREC), of multisensory convergence, 300, 301, 305, 306
 - Aversive conditioning, neuroimaging studies of, 573–574
 - Aversive tastes
 - activation of amygdala by, 567
 - representation in orbitofrontal cortex of, 565–567
 - Awareness, in odor-taste learning, 75–76
 - Azimuthal location, 251
- ## B
- Backup signal, 236
 - Balance control, haptic influences on, 421, 422
 - Balance disorders, multisensory integration in, 785, 796

- Baldi, 172–174
- Barbary doves, multisensory signals in, 232
- Barbecue spit rotation, multisensory influences on body orientation during, 419–420, 422
- Barn owl
intersensory integration in, 659
visual instruction of auditory space map in midbrain of, 613–623
- Basal forebrain, in memory encoding and storage, 337–338, 339
- Bathygobius soporator*, multisensory signals in, 230, 233
- Bayes' rule model, of multisensory enhancement, 266–271
behavioral relevance and decision theory in, 279–280
deriving testable prediction from, 271–274
future directions for, 278–280
information theoretic analysis of, 274–278
for multisensory neuron, 268–271
for unimodal neuron, 266–268
- BDNF (brain-derived neurotrophic factor), in tool use learning, 457, 458
- Bees, multisensory signals in, 229
- Beginner's Intelligibility Test* (BIT), after cochlear implantation, 760, 761
- Behavioral consequences, of multisensory integration, 252–254
- Behavioral correlates
of event-related potentials, 506, 510–511
of object recognition, 127–130
- Behavioral relevance, in Bayes' rule model, 279–280
- Bimodal neurons, 343
in superior colliculus, 246
- Binaural neurons, in superior olivary complex, 250–251
- Binaural unmasking, 89
- Biological motion, perception of, 453–454
- Bird(s)
differential effects of unimodal and multimodal stimulation in, 646–647
migration of, 235
redundant signals in, 228–229
- Bird-of-Paradise, multisensory signals in, 226
- Bisensory changes, infants' responses to, 666–667, 668–670, 671
- Bisensory facilitation, 662
- Bisensory learning, 672
- BIT (*Beginner's Intelligibility Test*), after cochlear implantation, 760, 761
- Blackbirds, multisensory processes in, 235
- Black-capped chickadees, multisensory signals in, 230
- Black-tailed prairie dog, multisensory signals in, 226
- Blindness
auditory behavior with, 695–696
compensatory plasticity with
intermodal/intersystem, 738–739
intramodal/intrasystem, 736
for language function, 727–731
model for investigating, 719–720
for motor development, 740
for perceptual functions, 723–725
perceptual training and, 736
via reorganization of polymodal brain areas, 737
for spatial functions, 731–734
cross-modal plasticity due to, magnetoencephalography of, 522–524
echolocation abilities with, 695–696
sound localization with, 695–699
visual cortex in tactile perception with, 711–716
- Blood-oxygen-level-dependent (BOLD)
deactivation signals, 485, 487, 488, 497–498
- Bobwhite quails, sensory development in, 234
- Body
body schema of one's own, 453, 454
ikonic representations of, 453
neural representation of another's, 453–454
- Body image
developed through tool use, 455–457
of self and others, 459, 460
- Body motion, illusory, 409
- Body movements, perception of, 454
- Body orientation, multisensory influences on, 409–422
- Body schema, 819
developed through tool use, 455–457
mirror neurons and, 454–455
of one's own body, 453, 454
- BOLD (blood-oxygen-level-dependent)
deactivation signals, 485, 487, 488, 497–498
- Boole's inequality, 398
- Bootstrapping, 727
- Braille reading
and overall language development, 727
visual cortex in, 711–716, 722
- Brain defects, cross-modal plasticity due to, magnetoencephalography of, 524
- Brain-derived neurotrophic factor (BDNF), in tool use learning, 457, 458
- Brainstem, in audiovisual speech perception, 214
- Brightness
auditory intensity and perceived, 38
and loudness, 90, 92, 96
and pitch, 90, 91, 98–100
- British Sign Language (BSL), activation of auditory cortex by, 778
- Broca's area
in action understanding, 455
in sign language processing, 777–778
- Brodmann's area 42, in speech-reading, 774
- Brownian motion, 402
- BSL (British Sign Language), activation of auditory cortex by, 778
- C
- California ground squirrels, multisensory signals in, 226
- Canids, multisensory signals in, 227
- Cardiac orienting, to compound stimulus, 672
- Cat(s)
corticocortical connectivity of
cross-modal circuits in, 343–354
differential effects of unimodal and multimodal stimulation in, 646
higher-order, modality-specific cortical representations in, 343–344
intersensory integration in, 659
multisensory development in, 254–256, 484
absence in early developmental stages of, 631, 632
appearance of, 631
maturation of corticotectal influences in, 635, 636–638
multisensory cortical populations and, 635–638
receptive field consolidation and, 629
role of cortical inputs in, 634–635
role of experience in, 637–638, 639, 640
possible effect of orienting behavior on target-present prior probabilities in, 272–273, 274
superior colliculus of, 246–248, 252, 254
influences of anterior ectosylvian sulcus or rostral lateral suprasylvian sulcus on, 257–259
maturation of corticotectal influences in, 635, 636–638
maturation of sensory response properties in, 626–629
multisensory cortical populations and, 635–638
receptive field consolidation during development in, 629
role of cortical inputs in multisensory integration in, 634–635
sensory and multisensory development in, 626, 627
temporal integration in, 395–396

- visually deprived
 - anterior ectosylvian cortex
 - in, 696–697
 - auditory spatial representations
 - in, 732
- Catch trials, 396
- Categorization, in speech perception, 155
- Caudomedial (CM) belt area, 287
 - multisensory convergence in, 297–298, 299, 302
- Center of mass (COM), in postural control, 785, 790, 792
- Centrifuges, 410
- Centripetal force, 410
- Centrocerus urophasianus*, multisensory signals in, 227
- Cerebral akinetopsia, 49
- Channels, for communication, 225
- Chickadees, multisensory signals in, 230
- Chickens, multisensory signals in, 230, 232
- Chimpanzees
 - multisensory signals in, 225
 - tool use by, 820
- CI(s). *See* Cochlear implant(s) (CIs)
- Cichlid fish, multisensory communication in, 226, 229
- Clastrum, in audiovisual convergence, 483
- CM (caudomedial) belt area, 287
 - multisensory convergence in, 297–298, 299, 302
- Coactivation models, of response time, 399–403
- Coarticulation, 195–196
- Cochlear implant(s) (CIs), 749
 - as aid to lipreading, 751, 755
 - effect of cross-modal plasticity on, 779
 - fuzzy logical model of perception with, 167–168
- Cochlear implantation, audiovisual speech perception after, 749–768
 - Common Phrases test of, 755–756, 757–761
 - discussion of, 761–767
 - duration of deafness and, 754–755, 758, 760, 762–763, 766–767
 - Lexical Neighborhood Test of, 757
 - lipreading skills and, 765–766
 - with oral communication *vs.* total communication, 755, 757–758, 763–765
 - in postlingually deaf adults, 752–754
 - predictors of success with, 761
 - in prelingually deaf children, 754–761
 - sources of variation in, 754–755, 764–765
- Cognitive biases, in cross-modal dynamic capture, 57
- Cognitive strategies, in ventriloquism effect, 143
- Colinus virginianus*, sensory development in, 234
- Collateral sulcus, in grapheme-color synesthesia, 844
- Color(s), synesthetic
 - measures of competition for, 853, 854
 - measures of consistency of, 852–853
 - Color-graphemic synesthesia. *See* Grapheme-color synesthesia
- Color-phonemic synesthesia, neural correlates of, 862–863
- Color-taste learning, 76–77
- Color-temperature congruence, 98
- Color-word synesthesia, 70
- COM (center of mass), in postural control, 785, 792
- Common currency
 - and communication, 199–200
 - lack of, 198–199
 - and perceptually guided speaking, 199
 - in speech perception, 189–190
- Common format audiovisual speech perception, 204–207
 - neural implementation of, 215–216
- Common Phrases (CP) test, after cochlear implantation, 755–756, 757–761
- Communication
 - in animals, 225–236
 - common currency and, 199–200
- Communication channels, 225
- Communication displays, unimodal *vs.* multimodal presentation of, 646
- Compensatory masquerade, 723
- Compensatory plasticity
 - as consequence of sensory loss, 719–740
 - for language function, 727–731
 - mechanisms of, 735–739
 - model for investigating, 719–720
 - for motor development, 740
 - for perceptual functions, 723–726
 - for spatial functions, 731–735
 - in developing and adult brain, 738–739
 - maladaptive consequences of, 739–740
 - neural mechanisms of, 698–699
- Complete dominance model, of multisensory texture perception, 118
- Complex environments, auditory-visual integration in, 386–388, 390
- Compound stimulus, cardiac orienting to, 672
- Concept activation, in grapheme-color synesthesia, 845
- Concurrence, *vs.* redundancy, 664
- Conditional object-place response task, 324
- Conditioning
 - classical fear, neuroimaging studies of, 573–574
 - context in, 674
 - subthreshold, 674
- Conditioning effects, temporal synchrony and, 673–674
- Configural encoding, of odor-taste mixtures, 78–79
- Confrontation techniques, 800
- Congruence
 - cross-modal, 89–91, 93–94
 - perceptual *vs.* stimulus, 101–103
 - spatial, 102–103
- Congruence effect
 - and Garner interference, 88, 92
 - in selective attention, 87–89, 91–92
- Congruence interactions
 - cross-talk in, 95
 - decisional model of, 95, 98–101
 - early holistic processing in, 94
 - linguistic processes in, 95, 97–98
 - mechanisms underlying, 94–101
 - perceptual congruence and stimulus congruence in, 101–103
 - perceptual representations in, 95–97
 - semantic coding hypothesis of, 95, 98
- Conjunction(s), 662, 673
- Conjunction designs, for hemodynamic studies, 496–497
- Connectionist model, of multisensory texture perception, 119–120
- Constant-velocity self-motion, illusions of, 409
- Context, in conditioning, 674
- Context-free activation, in hemodynamic studies, 497
- Context independence, 398
- Contingent negative variation, 505
- Continuous attractor network, 326
- Contralaterally cued, 4n, 6, 7
- Convergence, in audiovisual integration, 204, 215–216
- Conversation(s), cooperative, 189
- Conversational distance, 178
- Cooperative conversations, 189
- Coriolis cross-coupling, 413–414
- Coriolis force(s), 410, 411
- compensation for, 416–417
 - in rotating environments
 - and arm movement control, 414–417
 - and head movement control, 414
 - self-generated, 416–417, 421–422
- Cortex
 - connection patterns that integrate modalities in, 285–291
 - multisensory integration in superior colliculus and, 254–257
 - rewiring of, 681–691
 - behavioral consequences of, 686–690
 - physiological and anatomical consequences of, 685–686, 687, 688
 - technique of, 683–685
- Cortical areas, in object recognition, 124–127
- Cortical deactivation, in hemodynamic studies, 498–499
- Cortical development and function, implications of cross-modal plasticity for, 681–691
- Cortical inputs, role in multisensory integration of, 634–635

- Cortical networks, for vision,
 - development of, 681–683
- Cortical processing, early multisensory
 - convergence in, 295–307
 - evidence of, 296–298
 - feedback, 299–303
 - feed-forward, 298–303
 - koniocellular input in, 303
 - mechanisms of, 298–303
 - sensory hierarchy for, 306–307
 - temporal parameters of, 295–296, 303–306
- Cortical remapping, 124, 125
- Cortical representations, higher-order,
 - modality-specific, 343–344
- Cortical synaptic hierarchy, subtypes
 - of, 210
- Corticocortical connectivity, of cross-modal circuits, 343–354
- Corticotectal inputs, in multisensory integration, 255
- Cossypha heuglini*, multisensory signals
 - in, 226
- Counter models, 400
- Count Raggi Bird-of-Paradise,
 - multisensory signals in, 226, 226f
- Coupled attractor networks, 322–324
- Courtship behavior, multisensory signals
 - in, 228, 229, 230, 232, 233, 235–236
- Covert attention, shifts of, 3, 4
- Covert spatial attentional orienting,
 - cross-modal cuing of, 3–21
 - early studies of, 5–7
 - electrophysiological evidence for, 17–20
 - psychophysical studies of, 16–17
 - using implicit spatial discrimination paradigm, 11–16
 - using orthogonal spatial cuing paradigm, 7–10, 15–16
- Cows, multisensory signals in, 229
- CP (Common Phrases) test, after
 - cochlear implantation, 755–756, 757–761
- Craniocentric coordinates, of visual input, 377–379
- Creativity, synesthesia and, 876–877
- Crickets, communication by, 227
- Criterion shifts, 16
- Critical periods, 720, 739
- Cross-activation hypothesis, of synesthesia, 870–872
- Crossed-tools condition, 825, 826, 827
- Cross-linkage model, of photisms, 844, 845
- Cross-modal asymmetries, in multisensory integration of dynamic events, 62–64
- Cross-modal attentional interactions,
 - functional imaging evidence for, 529–546
- Cross-modal bias, 583
- Cross-modal circuits, corticocortical
 - connectivity of, 343–354
- Cross-modal congruence, 89–91, 93–94
- Cross-modal consequences
 - of exogenous spatial orienting of attention, 3–21
 - of visual deprivation in animals, 695–699
- Cross-modal cuing
 - between audition, touch, and vision, 10–12
 - of exogenous spatial attention
 - asymmetry of, 6, 7
 - early studies of, 5–7
 - electrophysiological evidence for, 17–20
 - psychophysical studies of, 16–17
 - using implicit spatial discrimination paradigm, 11–16
 - using orthogonal spatial cuing paradigm, 7–10, 15–16
- Cross-modal dynamic capture, 53–54
 - across audition, touch, and vision, 60–64, 61t
 - attention in, 63
 - combining sounds, touches, and lights, 61–62
 - critical role of motion in, 54–57
 - levels of processing in, 57–60
 - modality dominance of, 62–64
- Cross-modal extinction
 - auditory-tactile, 809–810
 - effects of tool use on spatial nature of, 820–825
 - between touch and mirror reflections, 831–832
 - visuotactile, 802–805, 806, 807, 808–809
- Cross-modal facilitation, neural
 - depression as indication of, 511
- Cross-modal illusion, 244
- Cross-modal integration, 484
 - attention in, 63n
 - for emotion, neuroimaging studies
 - of, 563–576
 - magnetoencephalography of, 515–524
 - modulated by mirrors, 828–832
 - modulated by tool use, 819, 820–827
 - in pathological states, hemodynamic studies of, 495–496
- Cross-modal interactions, 91–93
 - before 200 ms latency, 506–509
 - cross-talk in, 95
 - decisional model of, 95, 96, 98–101
 - early holistic processing in, 94
 - in exogenous spatial attention, 539–542, 545
 - linguistic processes in, 95, 97–98
 - mechanisms underlying, 94–101
 - in near peripersonal space of fake hand, 805–807, 825
 - perceptual representations in, 95–97
 - in right temporofrontal scalp regions, 508–509
 - in selective attention, 89–94
 - semantic coding hypothesis of, 95, 98, 99f, 100
 - in sensory-specific areas, 506–508
- spatial frames of reference for, 542–546
- spatial specificity of, 539–542, 545
- in speeded classification, 85–103
- stimulus-driven, 539–542
- in superior colliculus, 508
- in visual cortex, 544
- Cross-modal interference
 - effects of tool use on, 825–827
 - between touch and mirror reflections, 828–831
- Cross-modal learning
 - amygdala in, 334
 - basal forebrain in, 337–338, 339
 - rhinal cortex in, 334–337, 339
- Cross-modal links
 - in endogenous spatial attention, 549–561
 - and activity of supramodal
 - attentional control mechanisms, 559–561
 - effect on early states of visual, auditory, and somatosensory processing of, 550–554
 - mediation by coordinates of external space of, 554–556
 - non-optional nature of, 556–557
 - in exogenous spatial attention, 557–558
- Cross-modal matching, 93, 484
- Cross-modal memory, in primates, 333–340
- Cross-modal mental imagery,
 - magnetoencephalography
 - of, 522
- Cross-modal modulation, visual
 - dominance over proprioception
 - in, 805
- Cross-modal paradigms, 396
- Cross-modal plasticity
 - and behavioral changes after sensory deprivation, 738–739
 - with deafness, 773–780
 - defined, 711
 - hemodynamic studies of, 495–496
 - in humans, 690–691
 - implications for cortical development
 - and function of, 681–691
 - intramodal *vs.*, 723
 - magnetoencephalography of, 522–524
 - as mechanism for compensation and hypercompensation, 735
 - period of susceptibility to experience, 712, 714, 715
 - between visual and somatosensory representations, 711–713
- Cross-modal priming, 484, 490
- Cross-modal processes, temporal
 - dynamics of, 509
- Cross-modal reassignment, 722, 737
- Cross-modal reorganization, attention
 - in, 698
- Cross-modal similarity, 93–94, 95, 96
- Cross-modal spatial integration, effects of
 - tool use on, 825–827
- Cross-modal stimulation, perceptual
 - effects of, 141–149

Cross-wiring, in synesthesia, 870–872
vs. disinhibition, 872
 and Stroop interference, 874
 Crowding effect, and grapheme-color
 synesthesia, 869–870, 871–872
 CSD (current source density)
 of multisensory convergence, 300, 301,
 305, 306
 of P1/N1 slow wave, 360, 361
 Cuban grassquits, multisensory processes
 in, 235
 Cue(s), *vs.* signals, 227
 Cued speech, 755
 Cuing effects, 3–4
Cupiennius salei, multisensory signals
 in, 232
 Current source density (CSD)
 of multisensory convergence, 300, 301,
 305, 306
 of P1/N1 slow wave, 360, 361
Cynia tenera, multisensory signals
 in, 229
Cynomys ludovicianus, multisensory signals
 in, 226

D

Database tests, in bimodal speech
 perception, 161
 Deactivation interactions, in
 hemodynamic studies, 498–499
 Deafness
 cochlear implantation for, audiovisual
 speech perception after,
 749–768
 compensatory plasticity with
 hemodynamic studies of, 496
 for language function, 731, 740
 magnetoencephalography of,
 522–523
 neuroimaging studies of, 773–780
 for perceptual functions, 725–726
 via reorganization of polymodal
 brain areas, 737
 for spatial functions, 734–735
 early-onset *vs.* late-onset, lipreading
 with, 751, 753
 fuzzy logical model of perception with,
 166–168
 language processing with,
 neuroimaging studies of,
 773–780
 lipreading in, 750–751, 753–754
 oral communication *vs.* total
 communication for, 755,
 757–758, 763–765
 speech tutoring for children with,
 172–174
 sudden *vs.* gradual, lipreading with,
 753–754
 vibrotactile activation of auditory
 cortex with, 777
 Decay parameter, 402–403
 Decisional model, of cross-modal
 interactions in selective
 attention, 95, 96, 98–101

Decision theory, in Bayes' rule model,
 279–280
 Deep brain structures, bimodal
 interactions in, 508, 510
 Deep superior colliculus (DSC)
 analysis and modeling of multisensory
 enhancement in, 265–281
 in audiovisual speech perception, 211
 functions of, 265
 multisensory enhancement in, analysis
 and modeling of, 265–281
 behavioral relevance and decision
 theory in, 279–280
 deriving testable prediction from,
 271–274
 future directions for, 278–280
 information theoretic analysis of,
 274–278
 for multisensory neuron, 268–271
 for unimodal neuron, 266–268
 organization of, 265
 Defensive movements
 examples of, 443, 444
 multisensory neurons for control of,
 443–451
 Delayed eye-movement tasks, area LIP
 and parietal reach region in, 464
 Delayed non-matching-to-sample (DNMS)
 task, 333, 334, 336–337
 Delayed reach tasks, area LIP and parietal
 reach region in, 464, 466,
 467–472
 Dense amnesia, 337, 338–339
 Density, multisensory perception of,
 108, 109
 Detection task, 505–509, 506–509
 Development
 of animals, multisensory processes in,
 234–235
 constructivist, epigenetic systems view
 of, 658
 of intersensory perception, 643–651
 Developmental differentiation view,
 657, 658
 Developmental factors, in multisensory
 redundancy, 658–659
 Developmental integration view,
 657, 658
 Developmental question, for intersensory
 perception, 657–658
 Differentiation view, of multisensory
 responsiveness, 643, 645
 Diffusion model, 402–403
 Diffusion processes, 402
 Dimensional interactions, in selective
 attention, 85
 Dimensional overlap, in congruence, 88
 Direct-access models, 142
 Directional information, multisensory
 integration of, 50–52
 Direct mapping, in audiovisual speech
 perception, 209
 Direct-matching hypothesis, of action
 understanding, 454
 Direct perception theory, 655–656
 of speech, 155

Direct-realist theory, of speech
 perception, 190, 197–198,
 206, 215
 Discriminability, in cross-modal
 interactions, 95
 Discrimination, in speech perception,
 168–174
 Disinhibition, in synesthesia, 872
 Displacing prisms, for ventriloquism
 aftereffect, 40
 DNMS (delayed non-matching-to-sample)
 task, 333, 334, 336–337
 Dogs, multisensory signals in, 232
 Dominance paradigms, for texture
 perception, 107, 108,
 109, 110
 Dorsal pathway, to parietal lobe, 126
 Doves, multisensory signals in, 232
 Drift rate, 402–403
 DSC. *See* Deep superior colliculus (DSC)
 Ducklings, differential effects of
 unimodal and multimodal
 stimulation in, 647
 Duplex perception, of speech, 196
 Dynamic events, multisensory
 integration between static
 and, 49–50, 52
 Dynamic information, multisensory
 integration of, 49–65

E

Early directing attention negativity
 (EDAN), 559
 Early holistic processing, in congruence
 interactions, 94
 ECD (equivalent current dipole), 508
 Echolocation abilities, in blind humans,
 695–696
 Edges, visual and auditory, 125
 Effectiveness, inverse, 386, 402, 483,
 503, 811
 Elderly, sensory reweighting in fall-prone,
 793–795
 Electroencephalography (EEG)
 of integration of phonetic
 information, 488
 magnetoencephalography *vs.*, 515, 517
 of multisensory affect perception,
 585–586
 of recognition of facial expressions in
 hemianopia, 592
 Electromagnetic inverse problem,
 515, 516
 Electrophysiological evidence, for
 cross-modal cuing of
 exogenous spatial attention,
 17–20
 Electrophysiological mechanisms, of
 audiovisual integration, 503–511
 Electrophysiological studies
 of integration of phonetic information,
 486, 487
 of multisensory affect perception,
 585–586
 of multisensory attention, 549–561

- Emotion(s)
 audiovisual perception of, 581–582
 attention in, 584–585
 conscious *vs.* nonconscious, 590–593
 electrophysiological studies of, 585–586
 in faces and voices, 582–584
 hemodynamic studies of, 494–495
 models for, 593
 neuroanatomy of, 586–589
 selective pairing mechanism in, 589–591
 time course of, 585–587
 cross-modal integration for, neuroimaging studies of, 563–576
 facial and vocal expression of, 582–584
 hyperconnectivity and, 877–878
 multisensory perception of, 581–594
 perception of, 165
- Endogenous attention, in ventriloquism effect, 144
- Endogenous selection, of relevant locations, 533–536
- Endogenous spatial attention
 cross-modal links in, 549–561
 and activity of supramodal attentional control mechanisms, 559–561
 and early states of visual, auditory, and somatosensory processing, 550–554
 mediation by coordinates of external space of, 554–556
 non-optional nature of, 556–557
 possible control structures for, 536–539, 546
 unimodal and multimodal modulations in, 532–539, 545
- Energy integration model, 400
- Energy summation hypothesis, 400
- Epigenetic factors, that align visual and auditory maps in ferret midbrain, 599–610
- Epigenetic systems view, of development, 658
- Episodic memory(ies), hippocampus in, 324–325, 337
- Equids, multisensory communication in, 226
- Equilibrium-point theories, of movement control, 414–415
- Equivalent current dipole (ECD), 508
- Erithacus rubecula*, multisensory signals in, 230
- Error reduction, with noisy communication channels, 225
- Escape responses, multisensory signals in, 233
- Event identity, pairings based on, 581–582
- Event-related potentials (ERPs)
 before 200 ms latency, 506–509
 additive model for, 504–505
 anticipatory slow potentials with, 505
 auditory-visual interactions in, 30, 31
 behavioral correlates of, 506, 510–511
- with blindness
 for language perception, 728
 for perceptual functions, 724–725
 for spatial functions, 732
 of cross-modal links in endogenous spatial attention, 550–561
 affecting early stages of processing, 550–554
 mediation by coordinates of external space in, 554–556
 as non-optional processing strategy, 556–557
 supramodal attentional control mechanisms in, 559–561
 of cross-modal links in exogenous spatial attention, 557–558
 of exogenous cross-modal spatial attention, 17–20
 general considerations with, 504–505
 implications of, 509–511
 of integration of phonetic information, 486
 of multisensory affect perception, 585
 of multisensory convergence in cortical processing, 296
 polarity of, 504
 of recognition of facial expressions in hemianopia, 591
 of selectivity in audiovisual affect pairing, 590
 spatiotemporal information via, 504
 three experiments using, 505–506
 of visual perception with deafness, 726
- Evoked potential(s)
 auditory
 age of cochlear implantation and, 763
 in rat cortex, 361–362, 365
 multisensory
 intracellular correlates of, 363–365
 in rat cortex, 357–368
 somatosensory, 358, 359, 361, 362, 365
 neurogenesis of P1/N1 slow wave of, 359–361
 unimodal
 high-resolution cortical mapping of, 358–359
 neurogenesis of P1/N1 slow wave of, 359–361
 visual, auditory-visual interactions in, 30, 31
- Evoked potential mapping
 audiovisual, 362, 364, 366–367
 auditory/somatosensory, 360–362, 363–364, 365, 366–367, 368
 early studies on, 357
 high-resolution cortical, 358–359
 of multisensory cortex, 362–364
 somatosensory, 358, 359
- Excitatory-inhibitory multisensory neurons, 351–352, 353–354
- Executive brain, perceptuocognitive *vs.*, 425
- Exogenous attention, in ventriloquism effect, 144–145, 146
- Exogenous attentional orienting, 4
- Exogenous spatial attention
 cross-modal cuing of, 3–21
 asymmetry of, 7
 early studies of, 5–7
 electrophysiological evidence for, 17–20
 psychophysical studies of, 16–17
 using implicit spatial discrimination paradigm, 11–16
 using orthogonal spatial cuing paradigm, 7–10, 15–16
 cross-modal interactions in, 539–542, 545
 cross-modal links in, 557–558
- Expected multisensory integration, 405
- Experience, in multisensory development, 637–638, 639, 640
- Exploratory procedures, in object recognition, 128–129
- Externally generated inputs, 660
- External space, mediation of cross-modal links in endogenous spatial attention by, 554–556
- Exteroceptive senses, 373
- Exteroceptors, 244
- Extinction
 cross-modal
 auditory-tactile, 809–810
 visual-tactile, 802–805, 806, 807, 808–809
 effects of tool use on spatial nature of, 820–825
 as probe to investigate spatial multisensory interactions, 800–801
- Eye-centered reference frame, 466–473
 advantages of, 476
 with eye position gain, 468f, 473, 474
- Eye-centered representations
 of auditory stimuli in posterior parietal cortex, 473–475
 transformation of head-centered to, 475
- Eye-head coordination, to auditory-visual stimuli, 382–383, 389
- Eye-head orienting task, task dependence of auditory-visual integration on, 383–384
- Eye movement(s), in audiovisual speech perception, 182
- Eye movement registration, 396
- Eye position gain, eye-centered reference frame with, 468, 473, 474
- F
- F2 area, 432–433
- F2 ventrorostral-V6A/MIP circuit, 432–434
- F4 area
 anatomical location and functional properties of, 426–430, 432–433
 in control of reaching in space, 432–434

- and neurological deficits related to peripersonal space, 431–432
- role of multisensory integration in, 430–431
- F5 area, 426f, 434–435
- F5-PF circuit, 434–438, 455
- Face, visuotactile interactions near, 807–809
- Face features, horizontal size of, 177, 178
- Face movements, perception of, 454
- Face processing, 213
- Face recognition, haptic, 132
- Facial affect, perception of, 165
- Facial expression(s)
 - amygdala in processing of, 571–572
 - of emotions, 582–584
 - electrophysiological studies of, 585–587
 - orbitofrontal cortex in processing of, 570–571
- Facial gestures, imitation by infants of, 190–191, 192
- Facial luminance, in audiovisual speech perception, 181
- Facial motion, in speech perception, 182–183, 184–186
- Facial speech gestures
 - evidence for perception of, 192–194
 - recognition by infants of, 191–192
- Facilitation, 662
 - multisensory, 674
- FAES region, 254
 - auditory inputs to, 348
 - excitatory-inhibitory multisensory neurons in, 351–352
 - external afferents to, 345, 346
 - intrinsic cross-modal connectivity of, 349–351
 - location of, 343
 - and SIV, 353
 - in sound localization, 343
- Fall-prone elderly population, sensory reweighting in, 793–795
- Far peripersonal space, neuronal bases for multisensory processing of, 810–811
- Fat, mouth feel of, 319–321
- Fearful facial expressions, amygdala in processing of, 571–572
- Feature integration information-processing theories, of audiovisual speech perception, 215–216
- Feature integration theory, 856
 - and ventriloquism effect, 144
- Feedback, in sensory processing, 141, 142
- Feedback circuits, for multisensory convergence, 299–303
- Feedback projection, 617
- Feed-forward circuits, for multisensory convergence, 141, 298–303
- Feeding behavior, multisensory signals in, 228–229, 230
- “Feeling” speech, 777
- Ferret(s)
 - auditory behavior in visually deprived, 695, 697
 - epigenetic factors that align visual and auditory maps in midbrain of, 599–610
 - intersensory integration in, 659
 - routing visual inputs to auditory pathway in
 - behavioral consequence of, 686–690
 - physiological and anatomical consequences of, 685–688
 - technique of, 683–685
- Filehne illusion, 50
- Filtering task, selective attention as, 86, 91
- Fixation neurons, 374–376
- Flavor, representation of, 315, 573, 574
- Flavor-visual association memory, 336
- Flicker-fusion threshold, of visual stimuli, 38
- Flinching, 447–448
- FLMP (fuzzy logical model of perception), convergent and nonconvergent integration in, 162–163
- fMRI. *See* Functional magnetic resonance imaging (fMRI)
- Focused attention, visual-tactile interaction in, 405–406
- Focused attention paradigm, 396
- Focused attention task, integration rule assumptions for, 404
- Food, pleasantness of taste of, 314
- Food texture, response of orbitofrontal taste and olfactory neurons to, 319–321
- Fornix, in memory encoding and storage, 337, 338
- Foveation-based signal, for auditory space map, 617
- Frame of reference
 - of somatosensory system, 379
 - of visual *vs.* auditory system, 377–378
- Free parameters, in bimodal speech perception, 160
- Freezing phenomenon, 146–148
- Frontal lobe, multisensory areas in, 450
- Frontoparietal areas, in endogenous covert spatial attention, 536, 546
- Frontoparietal circuit
 - F2 ventrorostral-V6A/MIP, 432–434
 - F4-VIP, 426–432
- Frontoparietal network, 492, 493
- FST (fundus of superior temporal sulcus), connections to, 288
- Functional imaging, of multisensory spatial representations and cross-modal attentional interactions, 529–546
- Functional magnetic resonance imaging (fMRI)
 - of activation of auditory cortex by visual stimuli, 778
- of affective value of stimuli
 - gustatory, 566–567
 - olfactory, 568
- of amygdala and auditory reinforcers, 572
- of audiovisual associative learning, 495
- of audiovisual interactions relating to emotion, 495
- of audiovisual perception of emotion, 586–588
- of auditory areas during visual processing, 738
- of auditory localization with blindness, 734
- of color-phonemic synesthesia, 863
- of cross-modal plasticity, 496
- deactivation interactions in, 498–499
- of detection of changes in sensory events, 494
- of integration at semantic level, 489–490
- of integration of phonetic information, 486–488
- of language perception with blindness, 728, 729
- of linguistic interactions, 485
- mapping unimodal and multimodal brain areas with, 529–530, 531
- of multisensory convergence in cortical processing, 296
- of orbitofrontal cortex and amygdala in emotion, 564
- of processing of facial expressions, 570–571
- of spatial concordance, 493
- of spatial frames of reference for cross-modal interactions, 543–545
- of speech-reading, 774–775
- of stimulus-driven cross-modal interactions, 539–542
- of stimulus-reinforcer association learning, 573–576
- of visual cortex
 - during auditory and tactile processing, 738
 - in tactile perception, 705, 706, 707
- of visual perception with deafness, 725–726
- Functional reallocation, 735, 736–737
- Function words, processing by blind people of, 727, 728–729
- Fundamental frequency, in audiovisual speech perception, 203
- Fundus of superior temporal sulcus (FST), connections to, 288
- Fusiform face area, 213
- Fusiform gyrus
 - in audiovisual perception of emotion, 586, 587–588
 - cross-wiring in synesthesia of, 870–871
 - in grapheme-color synesthesia, 844–845
 - in visual speech pathway, 213

Fuzzy logical model of perception (FLMP)
 convergent and nonconvergent integration in, 162–163
 discrete *vs.* continuous information processing in, 163
 information *vs.* information processing in, 164–165
 learning in, 171
 of language, 172
 of speech-reading, 172
 of speech, 161–172, 198–199, 206–207
 of texture, 119, 141

G

Gain fields, eye-centered reference frame with, 468, 473, 474
Gallus domesticus, multisensory signals in, 230
 Gap saccade task, 375–376
 Garner interference, 87
 and congruence effect, 88, 92
 in cross-modal interactions, 92
 Garter snakes, multisensory signals in, 233–234
 Gating, of instructive signal for auditory space map, 618–619, 621
 Gaze location, in audiovisual speech perception, 182
 Gaze orienting, auditory-visual interactions subserving, 373–391
 Gaze saccade, 373, 374, 375
 Generalization, of tool use, 458–459
 Geometric properties, multisensory perception of, 108, 109
 Geons, object, 128
 Glutamate taste receptor, 314
 Goby fishes, multisensory signals in, 230, 233
 Grapheme-color synesthesia, 837–848, 851
 consistency of, 852–853
 crowding effect and, 869–870, 871–872
 effects of attentional load and rivalry on, 856–861
 effects of visual masking of inducing stimuli on, 853–856
 general principles of, 837, 838
 measures of competition in, 853, 854
 photisms in
 as automatic consequence, 838–839
 cross-linkage model of, 844, 845
 form and meaning in determining, 844–847
 location of, 837
 perceptual aspects of, 841–844
 reentrant model of, 844–845
 pop-out in, 869
 projectors *vs.* associators in, 837, 839–841, 847, 861, 862
 Stroop effect in, 840–841, 853, 860, 861–862

Grapholitha molesta, multisensory signals in, 235
 Grasp, coding of, 464–465
 Grassquits, multisensory processes in, 235
 Grating orientation, visual cortical involvement in tactile discrimination of, 703–704
 Gravito-inertial force
 effect on otolith organs of, 409–410
 during parabolic flight maneuvers, 413–414
 and somatogravic illusions and errors in visual and auditory localization, 411–412
 Grouse, multisensory signals in, 227
 “Guarding” posture, 447
 Gulls, multisensory communication in, 226
 Gustatory region, of insular cortex, 287
 Gustatory stimuli, neuroimaging studies of affective value of, 564–567

H

Hand, cross-modal interaction in near peripersonal space of fake, 805–807, 825
 Hand-rubbing experiment, 112
Haplochromis, multisensory signals in, 229
 Haptic-auditory integration, 111–112, 115–116
 Haptic face recognition, 132
 Haptic influences, on postural control and locomotion, 421, 422
 Haptic object agnosia, 127
 Haptic object recognition, 128–129
 Haptic priming, in visual object recognition, 126, 129
 Haptic space, 132
 Haptic system, 107
 Hardness, multisensory perception of, 120
 Hard-of-hearing children, teaching new vocabulary to, 174
 Head-centered reference frame, 467, 468
 transformation to eye-centered of, 475
 Head-centered visual receptive field, 449
 Head direction, and presubiculum, 326
 Head motions, in audiovisual speech perception, 185
 Head movement control, in rotating environments, 413–414
 Head-related transfer function (HRTF), 377
 Hearing aids, fuzzy logical model of perception with, 167–168
 Hearing loss. *See* Deafness
 Hebbian long-term potentiation, of auditory map plasticity, 621
 Hemianopia, recognition of facial expressions in, 591, 592

Hemispatial neglect, 434
 as probe to investigate spatial multisensory interactions, 801
 Hemodynamic studies, of audiovisual interactions, 483–499
 activation interaction designs for, 497–498
 approaches to, 484–485
 background for, 483–484
 deactivation interaction designs for, 498–499
 for detection of changes in sensory events, 494
 human imaging studies of, 485–496
 for integration at semantic level, 488–490
 for integration of phonetic information, 486–488
 intersection and conjunction designs for, 496–497
 linguistic, 485–490
 nonlinguistic, 491–494
 in pathological states, 495–496
 in priming studies, 490
 relating to associative learning, 495
 relating to emotion, 494–495
 for spatial concordance, 491–494
 for temporal correspondence, 491
 Heschl’s gyrus
 activation by visual stimuli of, 778–779
 in auditory speech pathway, 211, 212
 in speech-reading, 774
 Heterogeneous summation law, 229
 Hippocampus
 in memory encoding and storage, 337
 multisensory convergence in, 311, 324–326, 328
 Histological tracing, of multisensory pathways, 365–366
 Homologue area adaptation, 722
 “Homomorphic” percept, in speech perception, 196
 Honeybees, multisensory signals in, 229
 Horses, multisensory signals in, 232
 HRTF (head-related transfer function), 377
 Hypercompensation, 719, 735
 Hyperconnectivity hypothesis, of synesthesia, 872
 and emotions, 877–878
 Hypothalamus, response to satiety by, 314

I

ICC (central nucleus of inferior colliculus), in auditory localization pathway, 616
 ICX. *See* Inferior colliculus, external nucleus of (ICX)
 Identification, in speech perception, 155, 168–174
 IFG (inferior frontal gyrus), in detection of changes in sensory events, 494
 Ikonic representations, 453

- ILDs (interaural level differences), 377, 613, 614
- Illumination, in audiovisual speech perception, 181–182
- Illusions, 662–663
- Illusory flash effect, 28–29
- Illusory self-motion, 409, 418
- Image-based object recognition, 128, 129–130
- Image characteristics, in audiovisual speech perception, 179–184
- Imagery, visual
 - magnetoencephalography of, 522
 - synesthesia and, 873–874
 - in tactile perception, 707
- Implicit memory procedures, in odor-taste learning, 79–80
- Implicit spatial discrimination paradigm, cross-modal cuing of exogenous spatial attention using, 11–16
- Increasing specificity view, of intermodal development, 660
- Infants
 - cross-modal matching in, 93
 - heterogeneous summation in, 229
 - imitation of facial gestures by, 190–191, 192
 - imitation of modeled actions by, 663
 - intersensory illusions in, 662–663
 - motor babbings of, 453
 - multisensory neurons in, 633, 634
 - perception-action couplings in, 658
 - perception of amodal invariance by, 660, 663
 - perception of amodal stimulus properties by, 644
 - perception of intersensory equivalence in multisensory compounds by, 670–672
 - perception of multimodal information by, 644–645
 - temporal synchrony in, 644, 645, 661
 - perceptual development and origins of multisensory responsiveness in, 643–651
 - recognition of facial speech gestures by, 191–192
 - responses to bisensory changes by, 666–667, 668–670, 671
 - response to audiovisual speech and singing by, 668–670,
 - response to kinetically static and dynamic multisensory stimulation by, 665–668
 - responsiveness to multisensory compounds by, 665–672
 - solutions to problem of multisensory inputs in, 664–665
 - speech perception by, 191–192
 - uniqueness of intersensory integration in, 674
 - vocal imitation by, 191
- Inferior area 6, in control of defensive movements, 443, 444–448
- Inferior colliculus
 - central nucleus of (ICC), in auditory localization pathway, 616
 - external nucleus of (ICX)
 - adaptive plasticity of, 616, 617–622
 - alignment of auditory and visual maps in, 621
 - in auditory localization pathway, 616–623
 - instructive signal to, 617–622
 - timing problems in, 621–622
 - space-specific neurons in, 250, 251
- Inferior frontal gyrus (IFG), in detection of changes in sensory events, 494
- Inferior parietal lobule (IPL), in spatial concordance, 494
- Inferior pulvinar nucleus, in audiovisual speech perception, 211, 214
- Inferior temporal gyrus, in visual speech pathway, 213
- Inferior temporal lobe, mechanisms of memory encoding and storage in, 337–339
- Inferotemporal cortex, connections to, 288
- Information processing view, of intersensory integration, 656
- Inhibition of return (IOR), 5n
- Input ambiguity, and effect of multisensory integration, 276–278
- Instructive signal, for auditory space map, 617–620
 - effect of parietal occlusion of visual field on, 617, 618
 - gating of, 618–619, 621
 - maintenance role of, 619–620
 - nature and mechanisms of, 620–621
 - source of, 617–619
- Insula
 - cross-modal interactions in right, 509
 - in detection of changes in sensory events, 494
 - in spatial concordance, 492
 - in temporal correspondence, 491
- Insular cortex, connections of, 287–288
- Insurance, with noisy communication channels, 225
- Integral dimensions, in selective attention, 86–87
- Integration principles, 503
- Integration view, of multisensory responsiveness, 643, 645
- Intensity hypothesis, 664
- Intensity parameter, 400
- Interaction effects, in hemodynamic studies, 497
- Interarrival times, 400
- Interaural level differences (ILDs), 377, 377f, 613, 614
- Interaural time differences (ITDs)
 - adaptive shift in map of, 616, 618
 - in auditory encoding, 376, 377
 - as auditory localization cue, 613, 614
 - effect of prismatic experience on, 615–616
 - effect of restricted lesion in optic tectum on, 619
 - sensitivity of superior olivary complex neurons to, 250–251
- Interference resistance, in odor-taste learning, 76–77
- Intermediate reference frame, 467, 468, 475
- Intermodal development, increasing specificity view of, 660
- Intermodal invariances, 484–485
- Intermodal plasticity, 723, 735, 738–739
- Internally generated inputs, 659–660
- Interoceptors, 244
- Interpersonal distance, in audiovisual speech, 178, 179–181, 180
- Intersection designs, for hemodynamic studies, 496–497
- Intersensory confusion, 657, 658, 673
- Intersensory equivalence, in multisensory compounds, 670–672
- Intersensory illusions, 662–663
- Intersensory integration, in infants, 657–658, 674
- Intersensory matching, rate-based, 670
- Intersensory perception, defining developmental question for, 657–658
- Intersensory perceptual development, 643–651
 - multisensory redundancy in, 655–675
 - theoretical conceptions of, 657
- Intersensory redundancy
 - defined, 664
 - in early perceptual development, 647, 648–651
- Intersensory redundancy hypothesis, 652–653
- Interstimulus interval (ISI), in cross-modal dynamic capture, 55
- Intersystem plasticity, 723, 735, 738–739
- Intramodal plasticity, 723, 735, 736
- Intraparietal sulcus (IPS)
 - in awareness of self and others, 459
 - and body schema, 454
 - connections to, 288–289
 - cortex of, 286
 - endogenous spatial attention in, 534, 535, 538
 - multisensory convergence in, 296–297, 305
 - in spatial concordance, 492
 - spatially specific bimodal effects for vision and touch in, 531, 532
 - in tactile discrimination of grating orientation, 704
 - in tool use, 455–458, 820
- Intrasystem plasticity, 723, 735, 736

Inverse effectiveness, 386, 402, 483, 503, 811
 Inverse gain reweighting, 791–793
 IOR (inhibition of return), 5n
 IPL (inferior parietal lobule), in spatial concordance, 494
 IPS. *See* Intraparietal sulcus (IPS)
 Ipsilaterally cued, 4n, 6, 7
 Irrelevant stimuli, 94, 99–100
 ISI (interstimulus interval), in cross-modal dynamic capture, 55
 ITDs (interaural time differences), 376, 377

J

Jaw movements, in speech perception, 182
 Jensen's inequality, 397
 Jumping spiders, multisensory signals in, 232

K

KA (auditory koniocortex), in auditory speech pathway, 211
 Kinematics-based animation, 186
 Kinetically static and dynamic multisensory stimulation, response to, 665–668
 Koniocellular input, in multisensory convergence, 303
 Kullback-Leibler divergence, 276–278

L

Language
 learning of, 172
 and odor-taste synesthesia, 73
 rules of, 153
 Language development, with deafness, 773–780
 Language function, compensatory plasticity as consequence of sensory loss for, 727–731, 740
 Language lateralization
 in blind people, 727, 728, 729
 in deaf people, 777–778
 Language processing, with deafness, 773–780
 Laridae, multisensory communication in, 226
 Late directing attention positivity (LDAP), 559, 560, 561
 Latent inhibition, 77
 Lateral geniculate nucleus (LGN)
 and ocular dominance columns, 682
 in visual speech pathway, 211, 213, 244
 Lateral intraparietal area (LIP)
 in audiovisual convergence, 483, 484
 common spatial representation in parietal reach region and, 466–474
 connections to, 288, 289
 cortex of, 286
 in movement planning, 464, 465, 466
 multisensory convergence in, 296

Lateral occipital complex (LOC)
 in object recognition, 126
 haptic, 31
 in tactile discrimination, 704, 705, 706, 707
 in visual speech pathway, 213
 Lateral occipital gyrus, endogenous spatial attention in, 534–535
 Lateral pulvinar nucleus, in audiovisual speech perception, 211, 214
 Lateral sulcus (LS), multisensory convergence in, 296–297, 450
 Lateral suprasylvian cortex, and multisensory integration in superior colliculus, 634–635
 Lateral suprasylvian sulcus
 in multisensory integration, 255, 256–257
 in superior colliculus-mediated orientation behavior, 257–259
 Law of heterogeneous summation, 229
 LDAP (late directing attention positivity), 559, 560, 561
 Learning
 about multisensory properties of objects and events, 333–340
 associative
 magnetoencephalography of, 520–522
 in multisensory integration, 328
 in fuzzy logical model of perception, 171
 of language, 172
 multisensory signals in, 233–235
 odor-taste, 72, 74–78
 of speech-reading, 171–172
 stimulus-reinforcer association, neuroimaging studies of, 563–564, 573–576
 Learning-dependent multisensory processing, magnetoencephalography of, 519–522
 Lemurs, multisensory signals in, 233
 Lesion-induced plasticity, 736
 Lexical Neighborhood Test, after cochlear implantation, 757
 LGN (lateral geniculate nucleus)
 and ocular dominance columns, 682
 in visual speech pathway, 211, 213, 244
 Lightness, and pitch, 92, 93, 95–97
 Light-touch/vision paradigm, for postural control, 789–793
 Liking, and odor sweetness, 72
 Limb-centered reference frame, 467, 468
 Limb-centered visual receptive field, 449
 Linear acceleration, effect on otolith organs of, 409–410
 Linear integration models, of multisensory texture perception, 118–119
 Lingual gyrus, in exogenous spatial attention, 541

Linguistic interactions, hemodynamic studies of, 485–490
 Linguistic processes, in cross-modal congruence interactions, 95, 97–98
 LIP. *See* Lateral intraparietal area (LIP)
 Lip gestures, imitation by infants of, 190
 Lip movements, in speech perception, 182
 Lipreading, 208–209
 age of cochlear implantation and, 754–755, 763
 auditory cortex in, 31
 cochlear implants as aid to, 751, 755, 763, 765–766
 cortical activation during, 213
 in early-onset *vs.* late-onset deafness, 751, 753
 in hearing-impaired adults, 750–751
 hemodynamic studies of, 485, 486–487
 learning of, 171–172
 magnetoencephalography of, 518
 neuroimaging studies of, 773–776, 777
 in normal hearing, 749–750
 robustness of, 165
 spatial and temporal constraints on, 177–186
 with sudden *vs.* gradual hearing loss, 753–754
 Tadoma method of, vibrotactile activation of auditory cortex in, 777
 tongue movements in, 209n
 variable skills in, 751
 Lipreading tasks, 177–178
 LOC. *See* Lateral occipital complex (LOC)
 Locations, endogenous selection of relevant, 533–536
 Locomotion, haptic influences on, 421, 422
 Lombard effect, 189
 Long-term depression (LTD), of auditory map plasticity, 621
 Long-term potentiation (LTP), of auditory map plasticity, 621
 Loudness, brightness and, 90, 93, 96
 LS (lateral sulcus), multisensory convergence in, 296–297, 450
 LTD (long-term depression), of auditory map plasticity, 621
 LTP (long-term potentiation), of auditory map plasticity, 621
Luscinia megarhynchos, learning in, 234

M

Macaque monkey
 control of defensive movements in, 443–451
 cortical sites for audiovisual convergence in, 483, 484
 cross-modal learning in, 333–340
 inferior temporal lobe in, 337–339
 rhinal cortex in, 334–337

- F2 ventrorostral-V6A/MIP circuit in, 432–434
- F4-VIP circuit in, 426–432
- F5-PF circuit in, 434–438
- multisensory signals in, 230–231, 232
- neocortex of, 285, 286
- perception of facial and body movements in, 454
- posterior parietal cortex in, 288–289
- tool use by, 820
- body image developed through, 455, 456
 - brain imaging studies of, 458
 - generalization of, 458–459
 - ventriloquism aftereffect in, 42–45
- Macrospace features, 705
- Macular degeneration, auditory localization with, 734
- Maevia inclemens*, multisensory signals in, 232
- Magnetic resonance imaging, functional. *See* Functional magnetic resonance imaging (fMRI)
- Magnetoencephalography (MEG), 515–517
- advantages of, 515, 517
 - of audiotactile integration, 518–519
 - of audiovisual associative learning, 520–522
 - of audiovisual integration, 518
 - of auditory processing in musicians, 724
 - of cross-modal integration and plasticity, 515–524
 - of cross-modal mental imagery, 522
 - of cross-modal plasticity, 522–524
 - of integration of phonetic information, 488
 - of learning-dependent multisensory processing, 519–522
 - of multisensory affect perception, 585
 - of multisensory convergence in cortical processing, 296
 - principles and instrumentation of, 515–516
 - of real-time multisensory processing, 518–519
 - spatial resolution of, 517
 - temporal resolution of, 517
 - uses of, 517
 - of vibrotactile activation of auditory cortex, 777
 - of visuotactile integration, 519
- Magnocellular layer, in visual speech pathway, 213
- Magpies, redundant signals in, 228
- Manner feature, in speech perception, 204n
- Map expansion, 722–723, 736
- Mark test, 459
- Material properties, multisensory perception of, 108, 109, 120–121
- Mating behavior, multisensory signals in, 228, 229, 230, 232, 233, 235–236
- Maximum-likelihood integration model, of multisensory texture perception, 119
- McGurk effect, 27, 203
- in audiovisual speech perception, 177, 205, 207–208, 750
 - as example of emergence, 234
 - familiarity with talker and, 207, 208
 - gaze during, 182
 - haptic version of, 189
 - in infants, 662
 - with low spatial resolution, 180
 - magnetoencephalography of, 518
 - and multimodal speech perception, 156, 159
 - multisensory convergence and, 311, 322, 323–324
 - positron emission tomography of, 488
 - sensitivity to asynchrony in, 183
 - and special nature of speech, 154
 - in speech perception by infants, 191
- McGurk effect tasks, 177–178
- Medial auditory belt, connections of, 287–288
- Medial geniculate nucleus (MGN)
- in audiovisual speech perception, 211, 214
 - histological tracing of multisensory pathways in, 365, 366, 368
 - projections to anterior ectosylvian sulcus from, 345
 - routing visual inputs to, 683–686
- Medial intraparietal area (MIP), 426, 433–434
- connections to, 288, 289
- Medial prefrontal cortex, connections to, 290
- Medial pulvinar nucleus
- in audiovisual convergence, 483
 - in auditory speech pathway, 211, 212, 214
- Medial superior temporal area (MST)
- connections to, 288
 - multisensory convergence in, 297, 301
- Medial temporal lobe, in object discrimination learning, 337
- MEG. *See* Magnetoencephalography (MEG)
- Memory(ies), episodic, 324–325, 337
- Memory encoding and storage, in inferior temporal lobe, 337–339
- Mental imagery
- magnetoencephalography of, 522
 - synesthesia and, 873–874
 - in tactile perception, 707
- Mental rotation, of two-dimensional tactile forms, visual cortex in, 704–706
- Metaphor, synesthesia and, 876, 877
- MGN. *See* Medial geniculate nucleus (MGN)
- Microspatial features, 705
- Midbrain
- epigenetic factors that align visual and auditory maps in, 599–610
 - multisensory integration in single neurons of, 243–260
 - visual instruction of auditory space map in, 613–623
- Midbrain tectum, with visual deprivation, 696
- Middle temporal gyrus (MTG)
- in audiovisual perception of emotion, 587–589
 - in auditory speech pathway, 212
 - integration at semantic level in, 489–490
 - in visual speech pathway, 213
- Middle temporal visual area (MT), 448
- multisensory convergence in, 297, 301, 303, 304
- Migration, of birds, 235
- Miller's test, 398
- MIP (medial intraparietal area), 426, 433–434
- connections to, 288, 289
- Mirror(s), cross-modal integration modulated by, 828–832
- Mirror-image stimuli, discrimination between, 705
- Mirror neurons
- in audiovisual speech perception, 215
 - and body schema, 454–455
 - in circuit for action understanding, 434–435
 - PF, 436–438
- Mirror reflections
- cross-modal interference between touch and, 828–831
 - cross-modal spatial extinction between touch and, 831–832
- Mismatch negativity (MMN), 585–586
- Misses, 396
- Modality appropriateness hypothesis, 27–28, 36
- and infants' responsiveness to multisensory compounds, 667
 - of multisensory texture perception, 116–118
- Modality dominance, of cross-modal dynamic capture, 62–64
- Modality-specific audiovisual speech perception, 207–210
- neural implementation of, 216–218
- Modality-specific cues, in perception of amodal invariant, 661–662
- Modality-specific stimulus properties defined, 660
- examples of, 644
 - intersensory redundancy and perceptual learning about, 649
 - perception by infants of, 644
 - specification of multisensory object or event by, 660
- Model tests, in bimodal speech perception, 161
- Modularity, in speech perception, 155
- Mole rats, multisensory signals in, 234

- Monaural spectral cues, 613
- Monkey
 - absence of multisensory integration in
 - early developmental stages of, 631
 - control of defensive movements in, 443–451
 - cortical sites for audiovisual
 - convergence in, 483, 484
 - cross-modal learning in, 333–340
 - inferior temporal lobe in, 337–339
 - rhinal cortex in, 334–337
 - F2 ventrostrual-V6A/MIP circuit in, 432–434
 - F4-VIP circuit in, 426–432
 - F5-PF circuit in, 434–438
 - multisensory signals in, 230–231, 232
 - neocortex of, 285, 286
 - perception of facial and body
 - movements in, 454
 - posterior parietal cortex in, 288–289
 - superior colliculus in, 246–248
 - superior colliculus of
 - maturation of sensory response
 - properties in, 626–629
 - receptive field consolidation during
 - development in, 630
 - sensory and multisensory
 - development in, 626, 627
 - tool use by, 820
 - body image developed through, 455, 456
 - brain imaging studies of, 458
 - generalization of, 458–459
 - ventriloquism aftereffect in, 42–45, 43, 44
- Morning warblers, multisensory processes in, 235
- Morphosyntactic priming, with blindness, 729–730
- Moths
 - multisensory integration in
 - interneuron of, 244
 - multisensory signals in, 229, 235
- Motion
 - apparent
 - across audition, touch, and vision, 60–62
 - in different modalities, 50–52, 54–57
 - influence of static events on
 - perception of, 49–50, 52
 - modality dominance with, 62–64
 - critical role in cross-modal dynamic
 - capture of, 54–57
 - illusory, 409
 - trajectory of
 - in different modalities, 50–52
 - influence of static events on, 50
 - visual cortical activation during tactile
 - perception of, 706
- Motion perception, sound alters vision in, 29
- Motion signals, multisensory integration of, 49–65
- Motor areas, in multisensory integration, 425–439
- Motor babbings, 453
- Motor cortex, sensory responses in, 443, 444–448
- Motor development, with blindness, 740
- Motor reference frame, 464
 - in superior colliculus, 248
- Motor representation, of perceived object, 431
- Motor representation hypothesis, 438–439
- Motor theory, of speech perception, 154–155, 190, 194–197
- Motor valence, of PF mirror neurons, 436
- Mouth, in smell and taste, 72–74
- Mouth movements, perception of, 213
- Movement control
 - equilibrium-point theories of, 414–415
 - multisensory influences on, 409–422
 - somatosensory influences on, 419–421
- Movement planning, posterior parietal cortex in, 464–466
- Moving events, multisensory integration between, 50–52
- MSE. *See* Multisensory enhancement (MSE)
- MST (medial superior temporal area)
 - connections to, 288
 - multisensory convergence in, 297, 301
- MT (middle temporal visual area), 448
 - multisensory convergence in, 297, 301, 303, 304
- MTG. *See* Middle temporal gyrus (MTG)
- MUA (multiunit activity), of multisensory convergence, 300, 301, 305
- Multichannel diffusion model, 402–403
- Multilinear regression, in audiovisual speech perception, 209–210
- Multimodal information, infant
 - perception of, 644–645
- Multimodal stimulation, differential
 - effects of unimodal and, 646–648
- Multimodal stimuli, fundamental
 - problems for orienting to, 376–379
- Multiple-messages hypothesis, 236
- Multisensory areas, in human brain, 450
- Multisensory communication, in animals, 225–236
 - descriptive observations of, 226–227
- Multisensory compounds
 - perception of intersensory equivalence in, 670–672
 - responsiveness to
 - by infants, 665–672
 - in other species, 672
- Multisensory confusion, 657, 658, 673
- Multisensory convergence
 - in amygdala, 311, 321
 - in attention, 326–328
 - in early cortical processing, 295–307
 - evidence of, 296–298
 - feedback, 299–303
 - feed-forward, 298–303
 - koniocellular input in, 303
 - mechanisms of, 298–303
- sensory hierarchy for, 306–307
- temporal parameters of, 295–296, 303–306
- in excitatory-inhibitory multisensory neurons, 351–352, 353–354
- in hippocampus, 311, 324–326, 328
- and McGurk effect, 311, 322, 323–324
- in orbitofrontal cortex, 311, 312, 328
- in temporal cortex, 321–324
- in transition zones between different sensory representations, 353
- Multisensory cortex
 - evoked potential mapping of, 362, 363, 364
 - resurrection in primates of, 285–291
- Multisensory depression, in deep superior colliculus, 265
- Multisensory development, 625–640
 - early absence of, 630–631, 632
 - future directions in, 638–640
 - maturation of corticotectal influences in, 635, 636–638
 - maturation of integrative properties in
 - multisensory neurons in, 631–633, 634
 - maturation of sensory response
 - properties in, 626–629
 - multisensory cortical populations in, 635–637, 638f
 - receptive fields and, 629–630, 631, 633
 - review of work on, 626, 627
 - role of cortical inputs in, 634–635
 - role of experience in, 637–638, 639, 640
 - stages of, 635, 638
- Multisensory enhancement (MSE)
 - Bayes' rule model of, 266–271
 - behavioral relevance and decision theory in, 279–280
 - deriving testable prediction from, 271–274
 - future directions for, 278–280
 - information theoretic analysis of, 274–278
 - for multisensory neuron, 268–271
 - for unimodal neuron, 266–268
- in deep superior colliculus, analysis and modeling of, 265–281
- function of, 266
- percent, 265–266
- Multisensory-evoked potentials
 - intracellular correlates of, 363–365
 - in rat cortex, 357–368
- Multisensory facilitation, 674
- Multisensory index, 248, 250
- Multisensory influences, on orientation
 - and movement control, 409–422
- Multisensory inputs, solutions to problem of, 664–665
- Multisensory integration
 - absence in early developmental stages of, 630–631, 632
 - action as binding key to, 425–439
 - appearance of, 631
 - associative learning in, 328

- behavioral consequences of, 252–254
- conceptual model of, 390–391
- in cortex and superior colliculus, 254–255
- defined, 248, 250, 483, 497
- development of, 625–640
 - early absence of, 630–631
 - future directions in, 638–640
 - maturation of corticotectal influences in, 635, 636–638
 - maturation of integrative properties in multisensory neurons in, 631–633, 634
 - maturation of sensory response properties in, 626–629
 - multisensory cortical populations in, 635–637, 638
 - receptive fields and, 629–630, 631, 633
 - review of work on, 626, 627
 - role of cortical inputs in, 634–635
 - role of experience in, 637–638, 639, 640
 - stages of, 635, 638
- of dynamic information, 49–65
- expected, 405
- goals of, 438–439
- index of, 248, 250
- influence of task constraints on, 383–386, 389–390
- influence on saccade reaction times of, 379–382
- input ambiguity and effect of, 276–278
- maturation of receptive fields and, 631, 633
- mechanisms underlying, 250–252
- between moving events, 50–52
- physiological consequences of, 248–251
- in postural control, 785–796
 - ambiguities and, 785–787
 - light-touch/vision paradigm and, 789–793
 - sensory reweighting and, 787–789
 - in fall-prone elderly population, 793–795
- in single neurons of midbrain, 243–260
- spatial rule of, 503, 811
- between static and dynamic events, 49–50, 52
- in superior colliculus, role of cortical inputs in, 634–635
- temporal rule of, 503, 811
- with visual fixation, 384–386, 389–390
- Multisensory interaction, modeling time course of, 395–407
- Multisensory neuron(s)
 - in anterior ectosylvian sulcus, 347–352
 - centrally located, 353
 - excitatory-inhibitory, 351–352, 353–354
 - maturation of integrative properties in, 631–633, 634
 - neonatal, 633, 634
 - receptive fields of, 633
 - multiple overlapping, 246–248
 - in unimodal cortex
 - contribution of local inputs to, 348–352
 - correspondence with organization of external inputs of, 344–348
- Multisensory neuronal convergence, of taste, somatosensory, visual, olfactory, and auditory inputs, 311–329
- Multisensory pathways, histological tracing of, 365–366
- Multisensory perception, of emotion, 581–594
 - attention in, 584–585
 - conscious *vs.* nonconscious, 590–593
 - electrophysiological studies of, 585–586
 - in faces and voices, 582–584
 - models for, 593
 - neuroanatomy of, 586–589
 - selective pairing mechanism in, 589–590, 591
 - time course of, 585–587
- Multisensory perceptual contours, 306
- Multisensory processes, in animals
 - for attention and perception, 235
 - for development and learning, 233–235
 - function and evolutionary history of, 235–236
- Multisensory processing
 - learning-dependent, magnetoencephalography of, 519–522
 - real-time, magnetoencephalography of, 518–519
 - superior colliculus in, 373–376
- Multisensory redundancy
 - advantage of, 655
 - evidence of, 656
 - theoretical foundations for, 655–656
 - defined, 661
 - developmental factors in, 658–659
 - in development of intersensory perception, 655–675
- Multisensory responsiveness, perceptual development and origins of, 643–651
- Multisensory signals
 - in animals, 225, 226
 - classification of, 227–228
 - composite, 227, 228
 - cues *vs.*, 227
 - dominance of, 232–233
 - emergence of, 234
 - enhanced responses to, 229–230
 - equivalence of, 229
 - independence of, 232
 - modulation of, 233–234
 - nonredundant, 227–228, 230–234
 - redundant, 227–230
 - learning advantage of, 672–674
- Multisensory spatial representations, functional imaging evidence for, 529–546
- Multisensory stimulation, response to kinetically static and dynamic, 665–670
- Multisensory zone
 - audiovisual (MZav), 362, 364, 367
 - auditory/somatosensory (MZas), 362–366, 367–368
- Multiunit activity (MUA), of multisensory convergence, 300, 301, 305
- Musicians, auditory processing in, 724
- Mutual support, 321–322
- MZas (auditory/somatosensory multisensory zone), 362–366, 367–368
- MZav (audiovisual multisensory zone), 362, 364, 367
- N
- N1 response, decreased amplitude of, 511
- Nasality feature, in speech perception, 204n, 205
- Near peripersonal space
 - auditory-tactile interactions in, 809–810
 - neuronal bases for multisensory processing of, 801–802
 - visuotactile interactions in, 805–809
- Neglect
 - auditory-visual modulation of, 811–812
 - hemispatial, 434
 - as probe to investigate spatial multisensory interactions, 801, 810
 - spatial, 431
 - unilateral, parietal cortex and, 453
 - visual
 - bimodal stimulation for, 811–812
 - as probe to investigate auditory-visual interactions, 810
 - ventriloquism effect with, 145–146
- Neocortex, of monkeys, 285, 286
- Neonates (*see also* Infants)
 - multisensory neurons in, 633, 634
- Nerve growth factor (NGF), in tool use learning, 457
- Neural correlates, of synesthesia, 851–852, 862–864
- Neural depression, as indication of cross-modal facilitation, 511
- Neural implementation, of audiovisual speech perception, 210–215
 - common format, 215–216
 - modality-specific, 216–218
 - testing theories of, 218
- Neural integration, and saccade reaction time, 380–381, 389
- Neural plasticity, 720–723
 - classification of, 721–723
 - defined, 720, 722
 - intramodal *vs.* intermodal changes in, 723
 - intrasystem *vs.* intersystem changes in, 723
- Neuroanatomy, of audiovisual perception of emotion, 586–589

- Neurogenesis, and compensatory plasticity, 739
- Neuroimaging modalities, 503
- Neuroimaging studies
- of affective value of stimuli, 564–572
 - auditory, 572
 - gustatory, 564–567
 - olfactory, 567–569
 - somatosensory, 569–570
 - visceral and somatic representations of, 570
 - visual, 570–572
 - of cross-modal integration
 - in amygdala, 572
 - for emotion, 563–576
 - in orbitofrontal cortex, 573, 574
 - of cross-modal plasticity and language processing in deaf people, 773–780
 - of representation of flavor, 573, 574
 - of stimulus-reinforcer association learning, 573–576
- Neuromagnetic inverse problem, 515, 516
- Neuromagnetic signals, genesis of, 516
- Neuromagnetometers, 516
- Neuron(s), multisensory integration in single, 243–260
- Neuronal correlates, of object recognition, 124–127
- Neuronal plasticity, in ventriloquism illusion, 45–46
- Neuroplasticity. *See* Neural plasticity
- Neuropsychological evidence, of integrated multisensory representation of space, 799–814
- Neurotrophin(s), in tool use learning, 457–458
- Neurotrophin 3 (NT-3), in tool use learning, 457
- NGF (nerve growth factor), in tool use learning, 457
- Nightingales, learning in, 234
- N*-methyl-D-aspartate (NMDA) receptors, 367
- in midbrain auditory localization pathway, 616
 - in visual and auditory map registration, 606–607
- Noisy communication channels, 225
- Nonlinguistic interactions, hemodynamic studies of, 491–494
- Non-matching-to-sample (NMS) task, 334
- Nonredundant-cue identification task, 505–509
- Nonredundant signals, in animals, 227–228, 230–234
- Nose, in smell and taste, 72–74
- Novelists, synesthesia in, 876–877
- NT-3 (neurotrophin 3), in tool use learning, 457
- Nucleus of solitary tract (NTS), in taste pathway, 312, 314
- Number line, in synesthesia, 875–876
- O**
- Object-based visual search task, attention in, 326–328
- Object constancy, 123, 127–128
- Object discrimination learning, medial temporal lobe in, 337
- Object geons, 128
- Object recognition, 123–136
- behavioral correlates of, 127–130
 - experimental studies on, 130–135
 - for multiple objects, 132–135
 - for single objects, 130–132
 - haptic, 128–129
 - lateral occipital cortex in, 31
 - neuronal correlates of, 124–127
 - with odor-taste synesthesia, 73–74
 - spatial constraints on, 135–136
 - temporal constraints on, 136
 - verbal mediation in, 134–135
- Object segregation, 147
- Object similarity, multisensory perception of, 108
- Observation-execution matching (OEM) system, in audiovisual speech perception, 215
- OC (oral communication), audiovisual speech perception with, 755, 757–758, 763–765
- Occipital cortex, in tactile discrimination by blind subjects, 711
- Occipital visual areas
- in blindness, 738
 - differential activation of, 531
 - in endogenous spatial attention, 533–534, 536, 538
 - retinotopic organization of, 530, 543
- Occipitotemporal areas, in object recognition, 126
- Ocular dominance columns, development and plasticity of, 681–682, 683, 699
- Oculocentric coordinates
- of somatosensory input, 379
 - of visual input, 377–378, 389
- Oculogravic illusion, 411
- Odor(s)
- defined, 69
 - sweet, 69–72
 - liking and, 72
 - odor-taste learning and, 74
- Odor-learning system, 79
- Odor-odor learning, 80
- Odor perception
- odor-taste learning and, 80
 - role of learning in, 70
- Odor-taste learning, 72, 74–78
- acquisition and awareness in, 75–76
 - expectancy test of, 76, 77
 - extinction procedure for, 76
 - implicit memory procedures in, 79–80
 - and odor perception, 80
 - preexposure and training in, 77–78
 - retention and resistance to interference in, 76–77
- successive *vs.* simultaneous associations in, 75–76
- Odor-taste mixtures, configural encoding of, 78–79
- Odor-taste synesthesia, 69–81
- language and, 73
 - and object identification, 73–74
 - reliability of, 70
 - validity of, 70–72
- OEM (observation-execution matching) system, in audiovisual speech perception, 215
- Olfaction
- orthonasal, 69, 73
 - retronasal, 69, 72, 73
 - synesthesia between taste and, 69–81
- Olfactory neurons, response to texture of food by, 319–321
- Olfactory pathway, in primate brain, 313
- Olfactory representations, in primate cortex, rules underlying formation of, 315–316
- Olfactory sensory-specific satiety, 318–320
- Olfactory stimuli
- neuroimaging studies of affective value of, 567–569
 - representation of pleasantness of, 318–320
- Olfactory-to-taste associations, 311, 315
- Omnipause neurons (OPNs), 376
- Ontogenetic adaptations, 657
- Optic ataxia, 434
- Optic tectum (OT), visual instruction of auditory space map in, 613–623
- Oral communication (OC), audiovisual speech perception with, 755, 757–758, 763–765
- Orbital motion, direction of experienced, 419–421
- Orbitofrontal cortex
- activation of
 - by auditory stimuli, 572
 - by gustatory stimuli, 565–567
 - by olfactory stimuli, 567–569
 - by somatosensory stimuli, 569–570
 - by visual stimuli, 570–572
 - in emotion, neuroimaging studies of, 563–576
 - imaging methods for, 564
 - multisensory convergence in, 311, 312, 328
 - representation of flavor in, 315, 573, 574
 - representation of tastes in, 565–567
 - in representing affective value of stimuli, neuroimaging studies of, 564–572
 - response to satiety by, 314, 318–320
 - response to texture of food by, 319–321
 - rules governing formation of olfactory representations in, 315–316
 - secondary taste cortex in, 313
 - stimulus-reinforcer learning in, neuroimaging studies of, 563–564, 573–576
 - visual inputs to, 316–318

- Oriental fruit moths, multisensory signals in, 235
- Orientation
 - multisensory influences on, 409–422
 - in object recognition, 130–131
 - in scene recognition, 133–134
 - somatosensory influences on, 419–421
- Orientation behavior, superior
 - colliculus—mediated, anterior ectosylvian sulcus or rostral lateral suprasylvian sulcus and, 257–259
- Orientation selectivity, development of, 682–683, 685, 686
- Orienting, to multimodal stimuli, fundamental problems for, 376–379
- Orienting behavior, possible effect on target-present prior probabilities of, 272–274
- Orienting gaze shift, auditory-visual interactions subserving, 373–391
- Ornstein-Uhlenbeck process (OUP), 402
- Orthogonal spatial cuing paradigm, for exogenous spatial attention, 7–10, 15–16
- Orthogonal task, selective attention as, 86, 91
- Orthonasal olfaction, 69, 73
- OT (optic tectum), visual instruction of auditory space map in, 613–623
- Other-awareness, 459, 460
- Otolith organs
 - effect of gravito-inertial force on, 409–410
 - threshold measurements of, 417–419
- OUP (Ornstein-Uhlenbeck process), 402
- Overgeneralizations, reduced number of, in blind children, 727
- Owl
 - auditory consequences of altered visual experience in, 604–605
 - auditory spatial representations in visually deprived, 731–732
 - intersensory integration in, 659
 - sound localization in visually deprived, 696, 697
 - space-specific neurons in inferior colliculus of, 250, 251
 - visual instruction of auditory space map in midbrain of, 613–623
- P**
- P1/N1 slow wave, 359–360, 363, 364, 365
- Pan troglodytes*, multisensory signals in, 225
- Parabelt, of auditory cortex
 - in auditory speech pathway, 212–213
 - connections to visual cortex of, 286–287
- Parabolic flight maneuvers, gravito-inertial force during, 413–414
- Paradisaea raggiana*, multisensory signals in, 226
- Parahippocampal gyrus, in speech-reading, 775, 776
- Parameter estimation, in bimodal speech perception, 160
- Parchment-skin illusion, 112, 518
- Parietal area 7b, in control of defensive movements, 443, 444, 449–450
- Parietal cortex
 - in action understanding, 455
 - in audiovisual convergence, 483, 484
 - and body schema, 453
 - motor properties of, 425
 - posterior
 - connections to, 288–289
 - eye-centered representations of auditory stimuli in, 473–475
 - in movement planning, 464–466
 - multisensory representations of space in, 463–476
 - and unilateral neglect syndrome, 453
- Parietal lobe
 - dorsal pathway to, 126
 - multisensory areas in, 449–450
 - in ventriloquism illusion, 46
- Parietal reach region (PRR), 288, 289
 - common spatial representation in area LIP and, 466–474
 - in movement planning, 464, 465
- Parieto-occipital cortex (POC), in tactile discrimination of grating orientation, 703, 704
- Parieto-premotor areas, in multisensory processing of near peripersonal space, 802
- Parsing, of speech signal, 193–194
- Parus atricapillus*, multisensory signals in, 230
- Parvocellular layer, in visual speech pathway, 213
- Pathological states, hemodynamic studies of cross-modal integration in, 495–496
- Pattern association network, in orbitofrontal cortex, 316–317
- Pattern recognition
 - in speech perception, 155–156, 158–159
 - universal principle of perceptual cognitive performance in, 165
- PBK (*Phonetically Balanced–Kindergarten Test*), after cochlear implantation, 760, 761
- PCA (principal components analysis), of audiovisual speech production, 184
- Peabody Picture Vocabulary Test* (PPVT), after cochlear implantation, 760, 761
- PEG (posterior ectosylvian gyrus cortex), projections to anterior ectosylvian sulcus from, 344, 345, 346, 347
- Percent multisensory enhancement, 265–266
- Perception
 - and action, 425
 - in animals, 235
 - in direct realism, 198
- Perception-action couplings, in infants, 658
- Perceptual accessibility, 117
- Perceptual congruence, stimulus *vs.*, 101–103
- Perceptual cues, distinctions between types of, 659–663
- Perceptual development
 - intersensory redundancy in, 647, 648–651
 - and origins of multisensory responsiveness, 643–651
- Perceptual discrepancy paradigm, 117
- Perceptual effects, of cross-modal stimulation, 141–149
- Perceptual functions, compensatory plasticity as consequence of sensory loss for, 723–726
- Perceptual representations, in cross-modal congruence interactions, 95–97
- Perceptual segmentation, 147
- Perceptual training, after visual loss, 736
- Perceptuocognitive brain, executive *vs.*, 425
- Peripersonal space, 430–431
 - cross-modal integration of modulated by mirrors, 828–832
 - modulated by tool use, 819, 820–827
- far, neuronal bases for multisensory processing of, 810–811
- near
 - auditory-tactile interactions in, 809–810
 - neuronal bases for multisensory processing of, 801–802
 - visuotactile interactions in, 805–809
- neurological deficits related to, 431–432
- temporal pattern of multisensory convergence for, 305–306
- Perirhinal cortex, in cross-modal learning, 334–337, 339
- Perky effect, in synesthesia, 873–874
- PET. *See* Positron emission tomography (PET)
- PF area, 426f, 435–438
- Phantom limb(s)
 - cortical remapping with, 124
 - lack of perceptual plasticity associated with, 690–691
- Phantom limb pain, 739–740
- Phi phenomenon, 49, 61
- Phonetically Balanced–Kindergarten Test* (PBK), after cochlear implantation, 760, 761
- Phonetic gesture(s)
 - evidence for perception of, 192–194
 - recognition by infants of, 191–192

- Phonetic information, hemodynamic studies of integration of, 486–488
- Phonetic module, 195–196
in speech perception, 154–155
- Phonetic processor, in speech perception, 196
- Photism(s)
as automatic consequence of viewing graphemes, 838–839
cross-linkage model of, 844, 845
defined, 837
form and meaning in determining, 844–847
location of, 837
perceptual aspects of, 841–844
reentrant model of, 844–845
- Physiological plasticity, 721–722
- Piriform area, activation by olfactory stimulation of, 567, 568
- PIT (posterior inferior temporal cortex), in grapheme-color synesthesia, 844–845
- Pitch
and brightness, 90, 91, 98–100
and lightness, 92, 93, 95–97
and visual position, 91
- Pitch-forward head movements, in rotating environments, 413–414
- Pitch-size congruence, 98
- Place feature, in speech perception, 204n, 205
- Plasticity
anatomical, 721–722
of auditory space map, 616, 617–620
model for, 620–622
of auditory spatial processing in superior colliculus, 604–605, 606
compensatory
as consequence of sensory loss, 719–740
for language function, 727–731
mechanisms of, 735–739
model for investigating, 719–720
for motor development, 740
for perceptual functions, 723–726
for spatial functions, 731–735
in developing and adult brain, 738–739
maladaptive consequences of, 739–740
neural mechanisms of, 698–699
cross-modal
and behavioral changes after sensory deprivation, 738–739
with deafness, 773–780
defined, 711
hemodynamic studies of, 495–496
in humans, 690–691
implications for cortical development and function of, 681–691
intramodal *vs.*, 723
magnetoencephalography of, 522–524
as mechanism for compensation and hypercompensation, 735
period of susceptibility to experience, 712, 714, 715
between visual and somatosensory representations, 711–712, 713
intermodal, 723, 735, 738–739
intersystem, 723, 735, 738–739
intramodal, 723, 735, 736
intrasystem, 723, 735, 736
lesion-induced, 736
magnetoencephalography of, 515–524
neural, 720–723
classification of, 721–723
defined, 720, 722
intramodal *vs.* intermodal changes in, 723
intrasystem *vs.* intersystem changes in, 723
physiological, 721–722
use-dependent, 736
in ventriloquism illusion, 45–46
- Pleasant tastes
activation of amygdala by, 567
hunger and, 314
representation in orbitofrontal cortex of, 318–319, 320f, 565–567
- PMLS (posterior medial lateral suprasylvian cortex), projections to anterior ectosylvian sulcus from, 344, 345, 346, 347
- pMTG (posterior middle temporal gyrus), integration at semantic level in, 489–490
- PMv (ventral premotor) zone
in control of defensive movements, 443, 444–448
multisensory responses of, 289
- PO (posterior nucleus), histological tracing of multisensory pathways in, 365–366, 368
- POC (parieto-occipital cortex), in tactile discrimination of grating orientation, 703, 704
- Poets, synesthesia in, 876–877
- Polymodal brain areas, reorganization of, 735, 736–737
- Polysensory zone (PZ), in control of defensive movements, 443, 444–448
- Pop-outs, in grapheme-color synesthesia, 869
- Positron emission tomography (PET), 564
of activation of auditory cortex by visual stimuli, 778
of affective value of stimuli gustatory, 565–566, 567
olfactory, 567–568
of amygdala and auditory reinforcers, 572
of audiovisual associative learning, 495
of audiovisual interactions relating to emotion, 494–495
of audiovisual perception of emotion, 587, 589
of audiovisual priming studies, 490
of auditory localization with blindness, 732–734
of color-phonemic synesthesia, 863
of cross-modal plasticity, 496
of endogenous spatial attention, 533–536, 538
of integration at semantic level, 489
of integration of phonetic information, 488
of linguistic interactions, 485
of orbitofrontal cortex activation by auditory stimuli, 572
of orbitofrontal cortex in representation of flavor, 573
of spatial concordance, 493
of temporal correspondence, 491
of visual cortex in tactile perception, 703, 704–705, 706, 707
- Postcues, 16n
- Posterior cingulate gyrus, in speech-reading, 775, 776
- Posterior ectosylvian gyral cortex (PEG), projections to anterior ectosylvian sulcus from, 344, 345, 346f, 347
- Posterior inferior temporal cortex (PIT), in grapheme-color synesthesia, 844–845
- Posterior medial lateral suprasylvian cortex (PMLS), projections to anterior ectosylvian sulcus from, 344, 345, 346, 347
- Posterior middle temporal gyrus (pMTG), integration at semantic level in, 489–490
- Posterior nucleus (PO), histological tracing of multisensory pathways in, 365–366, 368
- Posterior parietal cortex (PPC)
connections to, 288–289
eye-centered representations of auditory stimuli in, 473–475
in movement planning, 464–466
multisensory representations of space in, 463–476
- Poststimulus time histograms (PSTHs), of auditory/somatosensory evoked potentials, 364, 365
- Postsynaptic potentials (PSPs), 364–365, 367
- Postural control
haptic influences on, 421, 422
multisensory integration in, 785–796
ambiguities and, 785–787
light-touch/vision paradigm and, 789–793
sensory reweighting and, 787–789
in fall-prone elderly population, 793–795

- Postural sway, 787–788, 796
 Potential actions, 431
 Potentiation, 672–673
 PPC. *See* Posterior parietal cortex (PPC)
 PPVT (*Peabody Picture Vocabulary Test*),
 after cochlear implantation,
 760, 761
 Prairie dog, multisensory signals in, 226
 Precentral gyrus, polysensory zone of, in
 control of defensive movements,
 443, 444–448
 Preexposure effect, 77
 in odor-taste learning, 77–78
 Prefrontal cortex
 in attention, 327
 in audiovisual convergence, 483, 484
 connections to, 290
 Prelabeling model, of audiovisual speech
 perception, 209
 Premotor cortex
 area F4 of
 anatomical location and functional
 properties of, 426–430, 432–433
 in control of reaching in space,
 432–434
 and deficits related to peripersonal
 space, 431–432
 role of multisensory integration in,
 430–431
 in audiovisual convergence, 483, 484
 connections to, 289–290
 polymodal neurons in, 425
 sensory responses in, 443, 444–448
 spatial representations in, 532
 Premotor saccade burst generator, 376
 Preparation enhancement model, 400
 Presubiculum, and head direction, 326
 Primates
 auditory-visual interactions subserving
 gaze orienting in, 373–391
 cross-modal memory in, 333–340
 intersensory integration in, 659
 multisensory signals in, 227
 olfactory pathway in, 313, 315–316
 resurrection of multisensory cortex in,
 285–291
 taste processing in, 312–314, 313f, 315f
 Priming, audiovisual, 490
 Principal components analysis (PCA), of
 audiovisual speech
 production, 184
 Prismatic spectacles, and auditory space
 map, 615–616
 Production-based animation, 185–186
 Projectors, in synesthesia, 837, 839–841,
 861, 862
 Proprioception
 in cross-modal dynamic capture, 62
 visual dominance over, in cross-modal
 modulation, 805
 PRR (parietal reach region), 288, 289
 common spatial representation in area
 LIP and, 466–474
 in movement planning, 464, 465
 Pseudophone, for ventriloquism
 aftereffect, 40
 PSPs (postsynaptic potentials), 364,
 365, 367
 PSTHs (poststimulus time histograms), of
 auditory/somatosensory evoked
 potentials, 364, 365
 Psychoacoustic accounts, of speech
 perception, 154
 Psychometric function, for ventriloquism
 aftereffect, 42, 43
 Psychophysical staircase methodology, for
 cross-modal dynamic capture,
 58–60
 Psychophysical studies, of cross-modal
 cuing of exogenous spatial
 attention, 16–17
 Putamen
 in control of defensive movements, 443,
 444, 450
 in cross-modal integration, 496
 in multisensory processing of near
 peripersonal space, 802
 PV region, 287
 PZ (polysensory zone), in control of
 defensive movements, 443,
 444–448
- ## Q
- Quail(s), sensory development in, 234
 Quail chicks
 differential effects of unimodal and
 multimodal stimulation in, 647
 intersensory redundancy and
 perceptual learning in,
 649–650
 responsiveness to multisensory
 compounds in, 672
 Quale, 244, 688
 Qualia, synesthesia and, 878–879
- ## R
- “Rabbit” effect, sound-induced
 visual, 29
 Race models
 of response time, 397–400
 of saccade reaction times, 379–380, 388
 Random dot kinematogram (RDK),
 apparent motion of, 51
 Rat(s)
 learning in, 234
 multisensory signals in, 234
 potentiation in, 673
 trace learning in, 674
 Rat cortex, multisensory evoked
 potentials in, 357–368
 Rate-based intersensory matching, 670
 RBD. *See* Right brain damage (RBD)
 RDK (random dot kinematogram),
 apparent motion of, 51
 RDLS-III (*Reynell Developmental Language
 Scales, 3rd Edition*), after cochlear
 implantation, 760
 Reach, coding of, 464, 465–466
 Reaching in space, circuit for control of,
 432–434
 Reaching movements, influence of
 Coriolis forces on, 415–417
 Reaction times, with event-related
 potentials, 506
 Reaction time studies, 16, 16n
 Real-time multisensory processing,
 magnetoencephalography of,
 518–519
 Receptive fields (RFs)
 maturation of multisensory integration
 and, 631, 633
 multiple overlapping, 246–248
 of multisensory neurons, 633
 in superior colliculus, 246, 247
 consolidation during development
 of, 629–630
 Reciprocal stimulus enhancement, 229
 Recognition, in speech perception, 155
 Redintegration, in odor-taste learning, 79
 Red jungle fowl, multisensory signals in,
 225, 226
 Redundancy, intersensory
 defined, 664
 in early perceptual development, 647,
 648–651
 Redundant-cue identification task,
 505–509
 Redundant signal(s), in animals, 227–230
 Redundant signal hypothesis, 236
 Redundant target effect, 506
 Redundant target paradigm, 396
 Redundant target task, integration rule
 assumptions for, 404–405
 Red-winged blackbirds, multisensory
 processes in, 235
 Reed warblers, redundant signals in, 228
 Reentrant model, of photisms, 844–845
 Reference condition, in hemodynamic
 studies, 497, 498
 Reference frame(s), 463
 advantages of common, 475–476
 in area LIP and parietal reach region,
 466–474
 eye-centered, 466–473
 advantages of, 476
 of auditory stimuli, 473–475
 with eye position gain, 468, 473, 474
 transformation of head-centered
 to, 475
 head-centered, 467, 468
 transformation to eye-centered
 of, 475
 intermediate, 467, 468, 475
 limb-centered, 467, 468
 spatial, for cross-modal interactions,
 542–546
 Reference-frame transformations,
 463–464
 posterior parietal cortex in, 464–476
 Relevant stimuli, 94, 99–100
 Reorganization, of polymodal brain areas,
 735, 736–737
 Repetitive transcranial magnetic
 stimulation (rTMS), for
 evaluation of visual cortex in
 tactile perception, 712

- Reptiles, multisensory signals in, 227
- Resistance to interference, in odor-taste learning, 76–77
- Response bias, in cross-modal dynamic capture, 57
- Response depression, with multisensory integration, 249, 251, 252–254, 483, 511
- Response enhancement, with multisensory integration, 229–230, 248–249, 252–254
- Response priming, 6, 7
- Response reversals, in ventriloquism effect, 143
- Response time (RT), 395–407
 coactivation models of, 399–403
 cross-modal paradigms for, 396
 as measure of multisensory interaction, 395–396
 multichannel diffusion model of, 402–403
 for saccadic eye movements, 396
 separate activation models of, 397–400
 superposition models of, 400–402, 403
 time-window-of-integration (TWIN) model of, 403–407
- Rest condition, in hemodynamic studies, 497, 498
- “Restricted influence” hypothesis, 407
- Retention, in odor-taste learning, 76–77
- Reticular burst neurons, 376
- Retinal ganglion cells, routing to auditory pathway of
 behavioral consequences of, 686–690
 physiological and anatomical consequences of, 683–686, 687, 688
 technique of, 683–685
- Retinotopic code, 376, 377
- Retinotopic organization, of occipital visual areas, 530, 543
- Retronasal olfaction, 69, 72, 73
- Rewards, for ventriloquism aftereffect, 42
- Reweighting, sensory, in postural control, 787–789
 in fall-prone elderly population, 793–795
 inverse gain, 791–793
 in light-touch/vision paradigm, 789–793
- Rewiring, of cortex, 681–691
 behavioral consequences of, 686–690
 physiological and anatomical consequences of, 685–686, 687, 688
 technique of, 683–685
- Reynell Developmental Language Scales, 3rd Edition* (RDLs-III), after cochlear implantation, 760
- RFs. *See* Receptive fields (RFs)
- Rhesus monkey
 multisensory signals in, 230–231, 232
 superior colliculus in, 246–248
- Rhinal cortex, in cross-modal learning, 334–337, 339
- Rhythm(s)
 amodal properties of, 644
 intersensory redundancy in learning of, 648–649
 tests of infants’ discrimination of, 661–662
- Right brain damage (RBD)
 auditory-tactile interactions with, 809–810
 auditory-visual interactions with, 810
 visual-tactile interactions with, 802–805
 with fake hand, 806, 825
 near face, 806–809
- Right insula, cross-modal interactions in, 509
- Right temporofrontal scalp regions, cross-modal interactions in, 508–509, 510
- Ring dove, multisensory communication in, 226
- Ring-tailed lemurs, multisensory signals in, 233
- Rise-to-threshold concept, in saccade initiation, 375
- Rivalry, in color-graphemic synesthesia, 856–861
- Robins, multisensory signals in, 230
- Root mean squared deviation (RMSD), in bimodal speech perception, 160–161, 163, 164
- Rostral lateral suprasylvian sulcus (rLS)
 in multisensory integration, 255, 256–257
 in superior colliculus-mediated orientation behavior, 257–259
- Rotating environments
 arm movement control in, 414–417
 head movement control in, 413–414
- Rotating vehicles, 410, 411
- Roughness, multisensory perception of, 108
 with audition, 111–112, 115–116
 with vision, 113–114
- RT. *See* Response time (RT)
- rTMS (repetitive transcranial magnetic stimulation), for evaluation of visual cortex in tactile perception, 712
- S
- S2 region, 287
- Saccade neurons, 374–376
- Saccade reaction times (SRTs), 396
 in complex environments, 387–388
 influence of multisensory integration on, 379–382, 388–389
 separate activation models of, 398, 399
 superior colliculus in, 391
 time-window-of-integration model of, 406
- Saccadic eye-head gaze shifts, superior colliculus in, 374, 375
- Sage grouse, multisensory signals in, 227
- Satiety, sensory-specific, 314, 315, 318–319, 320
 neuroimaging studies of, 568–569, 573, 574
- SC. *See* Superior colliculus (SC)
- Scalp current densities (SCDs), 504, 508
- SCBNs (superior colliculus burst neurons), 375, 376, 381–382, 388
- SCBUNs (superior colliculus buildup neurons), 375, 376, 381–382, 388, 389
- Scene analysis, 147
- Scene recognition, 132–135
- SCFNs (superior colliculus fixation neurons), 375, 376
- Schizocosa* spp, multisensory signals in, 228, 233
- Schizophrenia, deficits in cross-modal integration in, 496
- Second language learners, 174
- Seen speech. *See* Lipreading
- Segmentation, 147
- Selective adaptation, and speech perception, 196
- Selective attention
 to amodal stimulus properties during early development, 645–646
 in color-graphemic synesthesia, 856–861
 congruence effect in, 87–89
 cross-modal, 89–94
 Garner interference in, 87
 separable *vs.* integral dimensions in, 86–87
 speeded classification for study of, 85–86
- Self-awareness, 459, 460
- Self-generated inputs, 659–660
- Self-motion, illusory, 409, 418
- Semantic coding hypothesis, of cross-modal congruence interactions, 95, 98, 99, 100
- Semantic development, in blind people, 727, 728–731
- Semantic level, hematologic studies of integration at, 488–490
- Semantic priming, with blindness, 729–730
- Semicircular canals, effect of head movement on, 413
- Sensitive periods, 720
- Sensorimotor transformation, 463
- Sensory compensation, 719
- Sensory conflict paradigms, 107
- Sensory convergence, *vs.* sensory integration, 328–329
- Sensory cortex, primary, 245
- Sensory deprivation, cross-modal plasticity due to magnetoencephalography of, 522–524
 model for investigating, 719–720
- Sensory development, in superior colliculus, 626, 627

- Sensory dominance, 662
 - in texture perception, 107, 108, 109, 110
- Sensory events, detection of changes in, 494
- Sensory experience, and multisensory integration, 637–638, 639, 640
- Sensory hierarchy, in multisensory convergence, 306–307
- Sensory inhibition, 662
- Sensory integration, *vs.* sensory convergence, 328–329
- Sensory loss, compensatory plasticity as consequence of, 719–740
 - for language function, 727–731
 - mechanisms of, 735–739
 - for perceptual functions, 723–726
 - for spatial functions, 731–735
- Sensory map changes, 719–740
 - for language function, 727–731
 - mechanisms of, 735–739
 - model for investigating, 719–720
 - for perceptual functions, 723–726
 - for spatial functions, 731–735
- Sensory map registration, in superior colliculus, 599–610
 - developmental emergence of, 602–604
- Sensory Organization Test (SOT), 787–788, 793–795
- Sensory receptive fields
 - multiple overlapping, 246–248
 - in superior colliculus, 246, 247
- Sensory reference frames, 463–464
- Sensory representations, in superior colliculus, 246, 247, 599–601
- Sensory response properties, in superior colliculus, maturation of, 626–629
- Sensory reweighting, in postural control, 787–789
 - in fall-prone elderly population, 793–795
 - inverse gain, 791–792, 793
 - in light-touch/vision paradigm, 789–793
- Sensory-specific areas, cross-modal interactions in, 506–508
- Sensory-specific satiety, 314, 315, 318–319, 320
 - neuroimaging studies of, 568–569, 573, 574
- Sensory substitution, 719
- SEP(s) (somatosensory evoked potentials)
 - multisensory, mapping of, 361, 362, 365
 - unimodal
 - high resolution mapping of, 358, 359
 - neurogenesis of P1/N1 slow wave of, 359–360, 361
- Separable dimensions, in selective attention, 86–87
- Separate activation models, of response time, 397–399, 400f
- Sexual selection, multisensory processes in, 235–236
- SFG (superior frontal gyri), in spatial concordance, 492
- SG (supragenulate nucleus)
 - in audiovisual convergence, 483
 - histological tracing of multisensory pathways in, 365, 366, 368
- Shrimp, multisensory signals in, 234
- Signal(s), multisensory. *See* Multisensory signals
- Signal detection theory, 16–17
 - and cross-modal interactions, 98
 - for multisensory texture perception, 120
- Signal-to-noise ratio (S/N)
 - functional enhancement of, 203, 203n
 - and sound localization, 387
- Sign language
 - activation of auditory cortex by, 778–779
 - compensatory plasticity with
 - for language function, 731, 740
 - for spatial functions, 734–735
 - processing systems for, 777–778
 - visual movement detection with, 776
- Sign language aphasia, 777–778
- Similarity scaling method, 90
- Simple cells, of primary visual cortex, 250, 251
- Singing, response to, 668–670
- Singular value decomposition (SVD), for audiovisual speech production, 184, 185
- Sinusoidal vertical axis rotation (SVAR) technique, 789
- SIV region, 254
 - connection between FAES and, 353
 - excitatory-inhibitor multisensory neurons in, 351–352
 - intrinsic cross-modal connectivity of, 349–351
 - location of, 343
 - projections to, 345, 346
 - somatosensory inputs to, 348
- Slow-rotation rooms, 410
- SMA (supplementary motor area), in
 - detection of changes in sensory events, 494
- Smell
 - anatomy of nose and mouth in, 72–74
 - defined, 69
 - synesthesia between taste and, 69–81
- Smoothness, multisensory perception of, 113, 114–115
- S/N (signal-to-noise ratio)
 - functional enhancement of, 203, 203n
 - and sound localization, 387
- Snakes, multisensory signals in, 233–234
- Snapping shrimp, multisensory signals in, 234
- SOAs. *See* Stimulus onset asynchronies (SOAs)
- SOC (superior olivary complex)
 - binaural neurons in, 250–251
 - interaural time delay (ITD) sensitivity of, 250–251
- Softness, multisensory perception of, 120
- Somatic representation, of affective value of stimuli, neuroimaging studies of, 570
- Somatogravic illusions, 411–412
- Somatosensory area (SV), projections to
 - anterior ectosylvian sulcus from, 344, 345, 346, 347
- Somatosensory cortex
 - compensatory plasticity of, 738
 - evoked potential mapping of, 360–362
 - spatial organization of, 530
- Somatosensory evoked potential(s) (SEPs)
 - multisensory, mapping of, 361, 362, 365
 - neurogenesis of P1/N1 slow wave of, 359–360, 361
 - unimodal
 - high-resolution mapping of, 358, 359
 - neurogenesis of P1/N1 slow wave of, 359–360, 361
- Somatosensory influences, on
 - orientation and movement control, 419–421
- Somatosensory inputs, in auditory cortex, 297–298
- Somatosensory perception
 - with blindness, 724, 725
 - with deafness, 726
- Somatosensory processing, cross-modal
 - links with
 - in endogenous spatial attention, 552–554, 559–561
 - in exogenous spatial attention, 558
- Somatosensory receptors, in postural control, 785, 786
- Somatosensory response properties, in superior colliculus, maturation of, 626–627, 628
- Somatosensory stimuli, neuroimaging studies of affective value of, 569–570, 571
- Somatotopic coordinates, 449
- Somatotopic representation, 379
- SOT (Sensory Organization Test), 787–788, 793–795
- Sound
 - alteration of vision by, 27–32
 - in motion perception, 29
 - in other aspects, 28
 - in temporal aspects, 27–28
 - effect of vision on perceived spatial location of, 27
- Sound-induced illusory flash effect, 28–29
- Sound-induced visual “rabbit” effect, 29
- Sound localization
 - auditory cortex in, 696
 - with blindness, 695–699
- Sound localization deficit, in neglect, 810

- Space
 - multisensory representations in
 - posterior parietal cortex of, 463–476
 - peripersonal
 - cross-modal integration of
 - modulated by mirrors, 828–832
 - modulated by tool use, 819, 820–827
 - far, neuronal bases for multisensory processing of, 810–811
 - near
 - auditory-tactile interactions in, 809–810
 - cross-modal interactions in, 805–809
 - neuronal bases for multisensory processing of, 801–802
 - neurological deficits related to, 431–432
- Space flight, use of rotating vehicles during, 410, 411
- Space map
 - auditory. *See* Auditory space map
 - visual, 613, 614, 731
 - alignment of auditory and, 599–610, 621
- Space perception, circuit for, 426–432, 426–429
- Space-specific neurons, in inferior colliculus of owl, 250, 251
- Space-time coordinates, pairings based on, 581–582
- Spatial acuity, in visual system, 36–37
- Spatial attention
 - endogenous
 - cross-modal links in, 549–561
 - and activity of supramodal attentional control mechanisms, 559–561
 - effect on early states of visual, auditory, and somatosensory processing of, 550–554
 - mediation by coordinates of external space of, 554–556
 - non-optional nature of, 556–557
 - possible control structures for, 536–539, 546
 - unimodal and multimodal modulations in, 532–539, 545
 - exogenous
 - cross-modal cuing of, 3–21
 - asymmetry of, 6, 7
 - early studies of, 5–7
 - electrophysiological evidence for, 17–20
 - psychophysical studies of, 16–17
 - using implicit spatial discrimination paradigm, 11–16
 - using orthogonal spatial cuing paradigm, 7–10, 15–16
 - cross-modal interactions in, 539–542, 545
 - cross-modal links in, 557–558
- Spatial concordance, hemodynamic studies of, 491–494
- Spatial congruence, 102–103
- Spatial constraints
 - on audiovisual speech perception, 177–186
 - on cross-modal object recognition, 135–136
- Spatial cuing effect, 6n
- Spatial density, multisensory perception of, 108, 109
- Spatial discrimination task, 6, 7
- Spatial disparity, and ventriloquism aftereffect, 45
- Spatial distribution, of speech information, 182–183
- Spatial frames of reference, for cross-modal interactions, 542–546
- Spatial functions, compensatory plasticity as consequence of sensory loss for, 731–735
- Spatial information, from event-related potentials, 504
- Spatial location(s)
 - attention based on, 326–328
 - cross-modal attentional selection of, functional imaging evidence for, 529–546
- Spatial neglect, 431
- Spatial orientation, multisensory influences on, 409–422
- Spatial position, of audiovisual stimulus, 731
- Spatial representations
 - within and across modalities, 530–532
 - in area LIP and parietal reach region, 466–474
 - integrated multisensory
 - extinction and neglect as probes to investigate, 800–801
 - neuronal bases for, 801–802
 - neuropsychological evidence of, 799–814
 - multisensory
 - functional imaging evidence for, 529–546
 - omnipresent nature of, 813–814
- Spatial resolution
 - in audiovisual speech perception, 179–181
 - in visual speech perception, 179–182
- Spatial rule of integration, 503, 811
- Spatial specificity, 539–542, 545
- Spatial-temporal interactions, in ventriloquism effect, 39–40
- Spatial view, 325–326
- Speaking, common currency and perceptually guided, 199
- Speech
 - audiovisual
 - conditions for, 178–179
 - production-based animation in, 185–186
 - properties of, 765–767
 - response to, 668–670
 - as communicative activity, 189
 - frequency spectrum of, 179, 184
 - rate of, 178–179
 - special nature of, 153–154
 - as supramodal or amodal phenomenon, 189–200
- Speech articulation dynamics, common format metric based on, 206
- Speech gestures
 - evidence for perception of, 192–194
 - recognition by infants of, 191–192
- Speech information, spatial distribution of, 182–183
- Speech-in-noise perception tasks, 177–178, 180–181, 183–184
- Speech modalities, varying ambiguity of, 156–159
- Speech module, 153–154
- Speech movements, temporal characteristics of, 183
- Speech pathway
 - auditory, 211–213
 - visual, 211, 213–214
- Speech perception
 - as amodal, 190, 194–198
 - audiovisual
 - after cochlear implantation, 749–768
 - interactions during, 530
 - McGurk effect in, 177, 205, 207–208
 - spatial and temporal constraints on, 177–186
 - and ventriloquist effect, 27
 - bimodal
 - advantages of, 165–166
 - database and model tests in, 160–161
 - ecological variability in, 165
 - free parameters in, 160
 - fuzzy logical model of, 161–172
 - individual differences in, 164–165
 - nonintegration models of, 159, 160
 - as paradigm for psychological inquiry, 156
 - parameter estimation in, 160
 - root mean squared deviation in, 160–161
 - single-channel model of, 159, 160
 - testing model's predictions for, 160–161
 - underlying neural mechanism of, 162–164
 - with varying ambiguity of speech modalities, 156–159
 - in blind people, 727–728, 731
 - categorization in, 155
 - common currency in, 189–190
 - cross-modal, 189–199
 - direct, 155
 - direct-realist theory of, 190, 197–198, 206
 - fuzzy logical model of, 198–199, 206–207
 - identification and discrimination in, 155, 168–174
 - image characteristics in, 179–184

- by infants, 191–192
- modularity in, 155
- motor theory of, 154–155, 190, 194–197, 206
- pattern recognition in, 155–156, 158–159
- psychoacoustic accounts of, 154
- recognition in, 155
- selective adaptation and, 196
- as special case of multisensory processing, 153–174
- as supramodal, 190–192
- theories of, 154–156
- visual. *See* Lipreading
- Speech production
 - audiovisual, 184–185
 - compatibility effects in, 197
 - as perceptually guided, 189
- Speech-reading. *See* Lipreading
- Speech signal(s)
 - in audiovisual speech perception, 209–210
 - parsing of, 193–194
- Speech tutoring
 - for children with hearing loss, 172–174
 - in second language, 174
- Speeded classification
 - cross-modal interactions in, 85–103
 - paradigm of, 85–86, 101
- Speeded texture task, 110–111
- Spermophilus beecheyi*, multisensory signals in, 226
- Spiders, multisensory signals in, 227, 228, 233
- SPL (superior parietal lobule), in spatial concordance, 494
- Split-brain patients, cross-modal dynamic capture in, 55–57
- Spoken language, audiovisual properties of, 765–767
- Spoken word recognition
 - after cochlear implantation, in postlingually deaf adults, 752–754
 - with oral communication *vs.* total communication, 755, 757–758, 763–765
- SQUIDS (superconducting quantum interference devices), 516
- Squirrels, multisensory signals in, 226
- SRTs. *See* Saccade reaction times (SRTs)
- Stagewise processing, 141–142
- Staircase methodology
 - for cross-modal dynamic capture, 58–60
 - for ventriloquism effect, 143, 144–145
- Static events
 - influence on perceived trajectory of motion of, 50
 - influence on perception of apparent motion of, 49–50
 - multisensory integration between dynamic and, 49–50, 52
- Statistical facilitation, 379–380, 397
- STG (superior temporal gyrus)
 - in auditory speech pathway, 212
 - in speech-reading, 774–775
- Stiffness, multisensory perception of, 113, 120–121
- Stimuli, relevant *vs.* irrelevant, 94, 99–100
- Stimulus congruence, perceptual *vs.*, 101–103
- Stimulus-driven cross-modal interactions, 539–542
- Stimulus enhancement, reciprocal, 229
- Stimulus information processing, 210–211
- Stimulus onset asynchronies (SOAs), 207–208
 - in multichannel diffusion model, 402, 403
 - in multisensory integration between moving events, 51, 58–60
 - in superposition model, 401
 - in time-window-of-integration model, 404, 406
- Stimulus preexposure effect, 77
- Stimulus-reinforcer learning, in orbitofrontal cortex and amygdala, neuroimaging studies of, 563–564, 573–576
- Stimulus-response compatibility effects, 6
- STP (superior temporal polysensory area), 286, 288
 - multisensory convergence in, 296–297, 301, 303, 304, 305, 306
- Streptopelia risoria*
 - multisensory communication in, 226
 - multisensory signals in, 232
- Striate cortex, compensatory plasticity of, 738
- Stridulation, in crickets, 227
- Stroop dilution effect, 858
- Stroop effect, for grapheme-color synesthesia, 861–862
 - in projectors *vs.* associators, 840–841, 861, 862
 - reverse, 861–862
 - selective attention and, 860
- Stroop task, for grapheme-color synesthesia, 838–839, 853, 854
- Stroop task interference
 - cross-wiring and, 874
 - and ventriloquism effect, 142
- Structure-based object recognition, 128
- STS. *See* Superior temporal sulcus (STS)
- Subjective experience, visual cortex in, 125
- Subjective impression, 244
- Substantia nigra, inhibitory signal to deep superior colliculus from, 279
- Subthreshold conditioning, 674
- Summation, law of heterogeneous, 229
- Superconducting quantum interference devices (SQUIDS), 516
- Superior colliculus (SC)
 - aligning visual and auditory maps in, 600–603
 - in audiovisual convergence, 483, 810–811
 - in audiovisual integration, 503, 508, 656
 - in audiovisual speech perception, 162, 211, 214
- auditory consequences of altered visual experience in, 604–606
- in coordinated movement, 246
- cross-modal interactions in, 508
- functions of, 265
- location of, 245
- modality-specific neurons in cortex
 - send converging inputs to individual neurons in, 254
- multiple overlapping receptive fields of multisensory neurons in, 246–248
- multisensory development of
 - absence in early developmental stages of, 630–631, 632
 - future directions in, 638–640
 - maturation of corticotectal influences in, 635, 636–638
 - maturation of integrative properties in multisensory neurons in, 631–634
 - maturation of receptive fields and, 631, 633
 - maturation of sensory response properties and, 626–629
 - mechanisms underlying, 250–252
 - model of, 245–248
 - multisensory cortical populations and, 635–638
 - role of cortical inputs in, 634–635
 - role of experience in, 637–638, 639, 640
 - stages of development of, 635, 638
- multisensory enhancement in, analysis and modeling of, 265–281
 - behavioral relevance and decision theory in, 279–280
 - deriving testable prediction from, 271–274
 - future directions for, 278–280
 - information theoretic analysis of, 274–278
 - for multisensory neuron, 268–271
 - for unimodal neuron, 266–268
- multisensory integration in, 254–257
 - appearance of, 631
- in multisensory processing, 373–376
- organization of, 265
- in orientation behavior, 245–246
- plasticity of auditory spatial processing in, 604–605, 606
- receptive field consolidation during development in, 629–630
- response enhancement and response depression in, 250, 252–254
- in saccadic reaction time, 391
- sensory and multisensory development in, 626, 627
- sensory map registration in, 599–610
 - developmental emergence of, 602–604, 605
- sensory representations in, 246, 247, 599–601
- in temporal correspondence, 491
- temporal integration in, 395–396
- in visual fixation, 384–386

- Superior colliculus (SC) (continued)
 visual instruction of auditory space map in, 613–623
 visual signals in shaping of auditory responses in, 605–607
 in vitro study of visual-auditory convergence in, 607–609
- Superior colliculus buildup neurons (SCBUNs), 375, 376, 381–382, 388, 389
- Superior colliculus burst neurons (SCBNs), 375, 376, 381–382, 388
- Superior colliculus fixation neurons (SCFNs), 375, 376
- Superior frontal gyri (SFG), in spatial concordance, 492
- Superior occipital gyrus, endogenous spatial attention in, 534–535
- Superior olivary complex (SOC)
 binaural neurons in, 250–251
 interaural time delay (ITD) sensitivity of, 250–251
- Superior parietal lobule (SPL), in spatial concordance, 494
- Superior temporal gyrus (STG)
 in auditory speech pathway, 212
 in speech-reading, 774–775
- Superior temporal polysensory area (STP), 286, 288
 multisensory convergence in, 296–297, 301, 303, 304, 305, 306
- Superior temporal sulcus (STS)
 in audiovisual associative learning, 520, 521
 audiovisual convergence in, 296–297, 483, 484
 in audiovisual speech perception, 216, 217, 530
 in auditory speech pathway, 212–213
 in awareness of self and others, 459
 connections of multisensory cortex of, 288
 in cross-modal mental imagery, 522
 in endogenous covert spatial attention, 537, 538, 546
 integration of phonetic information in, 486–488
 in perception of face and body movements, 454
 in spatial concordance, 492
 in speech-reading, 774–775
 in visual speech pathway, 213
- Superposition models, 400–402, 403
- Supervised learning, of auditory space map, 617
- Supplementary motor area (SMA), in detection of changes in sensory events, 494
- Supragenulate nucleus (SG)
 in audiovisual convergence, 483
 histological tracing of multisensory pathways in, 365, 366, 368
- Supramodal attentional control systems, 21, 546, 559–561
- Supramodal systems, in spatial concordance, 492
- SV (somatosensory area), projections to anterior ectosylvian sulcus from, 344, 345, 346, 347
- SVAR (sinusoidal vertical axis rotation) technique, 789
- SVD (singular value decomposition), for audiovisual speech production, 184, 185
- Sweetness enhancement, 70, 71–72, 74
- Sweet odors, 69–72
 liking and, 72
 odor-taste learning and, 74
- Syllables, synthetic, 194–195
- Synchrony, amodal properties of, 644
- Synesthesia
 alphanumeric, and multisensory processing, 847–848
 angular gyrus in, 875, 877
 artists, poets, and, 876–877
 auditory-visual, 93
 behavioral and brain correlates of multisensory experience in, 851–864
 color-phonemic, neural correlates of, 862–863
 color-word, 70
 cross-activation hypothesis of, 870–872
 cross-wiring in, 870–872
 vs. disinhibition, 872
 and Stroop interference, 874
 defined, 93, 837, 867
 evidence for reality of, 868–869
 genetic basis of, 868
 grapheme-color, 837–848, 851
 consistency of, 852–853
 crowding effect and, 869–870, 871–872
 effects of attentional load and rivalry on, 856–861
 effects of visual masking of inducing stimuli on, 853–856
 general principles of, 837, 838
 measures of competition in, 853, 854
 photisms in
 as automatic consequence, 838–839
 cross-linkage model of, 844, 845
 form and meaning in determining, 844–847
 location of, 837
 perceptual aspects of, 841–844
 reentrant model of, 844–845
 pop-out in, 869
 projectors *vs.* associators in, 837, 839–841, 847, 861, 862
 Stroop effect in, 840–841, 860, 861–862
 higher *vs.* lower, 874–876
 hyperconnectivity hypothesis of, 872
 and emotions, 877–878
 and metaphor, 876, 877
 neural correlates of, 851–852, 862–864
 number line in, 875–876
 as perceptual *vs.* conceptual, 869–870, 875
 Perky effect in, 873–874
- and philosophical riddle of qualia, 878–879
- psychophysical investigations into, 869–870
- stability of associations over time in, 868–869
- Stroop interference in, 869
 between taste and smell, 69–81
 in temporal lobe epilepsy, 878
 theories of causation of, 867–868
 top-down influences in, 872–873
 and visual imagery, 873–874
- Synesthesia threshold, 872
- Synesthetic colors
 measures of competition for, 853, 854
 measures of consistency of, 852–853
- Synesthetic priming task, 853–856
- Synesthetic Stroop task, 853, 858
- Syntactic priming, with blindness, 729–730
- Syntax development, in blind people, 727, 728–731
- Synthetic syllables, 194–195
- Synthetic talking face, 172–174
- ## T
- Tactile apparent motion, 61–62
- Tactile discrimination
 by blind subjects, 712–715
 of grating orientation, visual cortical involvement in, 703–704
 visual cortex in, 30–31
- Tactile extinction, by visual modulation, 802–805, 806, 807, 808–809
- Tactile forms, visual cortex in
 perception of
 three-dimensional, 706
 two-dimensional, 704–706
- Tactile location, vision effect on, 27
- Tactile object agnosia, 127, 128
- Tactile perception
 with blindness, 724, 725
 contralesional
 enhancing, 804–805
 reducing, 803–804
 cross-modal interactions in, 92–93
 cross-modal modulation of, 805
 with deafness, 726
 visual cortex in, 703–708
 with blindness, 711–716
 for grating orientation, 703–704
 for mental rotation of two-dimensional form, 704–706
 for motion, 706
 for three-dimensional forms, 706
 visual modulation of, 802–805
 with fake hand, 805–807, 825
 near face, 807–809
- Tactile reference frames, 463–464
- Tactile-visual-auditory stimulus, test of separate activation model with, 398–399, 400
- Tadoma method, of speech-reading, vibrotactile activation of auditory cortex in, 777
- Tadpoles, multisensory signals in, 233

- Talking face, synthetic, 172–174
- Target-present prior probabilities,
 - possible effect of orienting behavior on, 272–274
- Target stimulus, attention and, 279
- Task constraints, influence on
 - multisensory integration by, 383–386, 389–390
- Task dependency, of audiovisual integration, 510
- Taste(s)
 - activation of amygdala by, 567
 - anatomy of nose and mouth in, 72–74
 - defined, 69
 - five basic sensations of, 69, 314
 - hunger and pleasantness of, 314
 - representation in orbitofrontal cortex of, 318–320, 565–567
 - synesthesia between smell and, 69–81
- Taste cortex
 - primary, 312
 - secondary, 313, 314
- Taste neurons, response to texture of food by, 319–321
- Taste-odor combination, intensity of, 73
- Taste processing, in primate brain, 312–315
- TC (total communication), audiovisual speech perception with, 755, 757–758, 763–765
- Teleost fishes, multisensory signals in, 233
- Template-based signal, for auditory space map, 617
- Tempo
 - amodal properties of, 644
 - intersensory redundancy in learning of, 649
- Temporal acuity, 38
- Temporal aspects, of vision, alteration by sound of, 27–28
- Temporal characteristics, of speech movements, 183
- Temporal constraints
 - on audiovisual speech perception, 177–186, 214–215
 - on cross-modal object recognition, 136
- Temporal correspondence, hemodynamic studies of, 491
- Temporal cortex, multisensory convergence areas in, 321–324
- Temporal dynamics, of cross-modal processes, 509
- Temporal information, from event-related potentials, 504
- Temporal integration rules, 395–396
- Temporal lobe, ventral pathway to, 126
- Temporal lobe epilepsy (TLE),
 - synesthesia in, 878
- Temporal order of judgment (TOJ) task
 - modal dominance in, 62n
 - for tool use, 827
- Temporal parameters, of multisensory convergence, 295–296, 303–306
- Temporal rule of integration, 503, 811
- Temporal-spatial interactions, in ventriloquism effect, 39–40
- Temporal stem, in cross-modal learning, 338
- Temporal synchrony
 - amodal properties of, 644, 664–665
 - and conditioning effects, 673–674
 - in infant perception of multimodal information, 644, 645, 661
 - intersensory, 674–675
 - model of intersensory integration based on, 652
 - and multisensory confusion, 673
 - and response of infants to bisensory changes, 671
- Temporofrontal scalp regions, cross-modal interactions in right, 508–509, 510
- Temporoparietal association cortex (Tpt),
 - in audiovisual convergence, 483, 484
- Temporoparietal cortex, in auditory speech pathway, 212
- Temporoparietal junction (TPJ)
 - in detection of changes in sensory events, 494
 - in endogenous covert spatial attention, 536, 537, 538, 546
 - in exogenous spatial attention, 541–542
 - non-spatial bimodal effects for vision and touch in, 531, 532
- Territorial behavior, multisensory signals in, 230
- Texture
 - defined, 107
 - of food, response of orbitofrontal taste and olfactory neurons to, 319–321
- Texture perception, multisensory, 107–121
 - effect on performance of, 112–116
 - empirical findings on, 107–116
 - integration of information in, 107–112
 - modeling of, 116–120
 - practical implications of, 121
 - results of studies on, 108
- Thalamic axons, in audiovisual speech perception, 214
- Thalamic modality-specific relay nuclei, compensatory plasticity of, 738
- Thalamus
 - in audiovisual convergence, 483
 - histological tracing of multisensory pathways in, 365–366, 368
 - in taste pathway, 312
 - visual responsiveness in auditory, 659
- Thamnopis radix*, multisensory signals in, 233–234
- Theta power, in object recognition, 127
- Three-dimensional tactile forms, visual cortex in perception of, 706
- Time course
 - of multisensory affect perception, 585–586
- of multisensory interaction, 395–407
- Time-window-of-integration (TWIN)
 - model, of response time, 403–407
- Timing problems, with auditory localization system, 621–622
- TLE (temporal lobe epilepsy), synesthesia in, 878
- TMS (transcranial magnetic stimulation)
 - for evaluation of visual cortex in tactile perception, 703–704, 707, 712, 715, 716
 - of selectivity in audiovisual affect pairing, 590, 591
- TOJ (temporal order of judgment) task
 - modal dominance in, 62n
 - for tool use, 827
- Tongue movements, in visual speech perception, 209n
- Tongue protrusion, imitation by infants of, 190–191
- Tonotopic code, 376, 377
- Tool use, 453–460
 - behavioral evidence of “generalization” in, 458–459
 - body image developed through, 455–457
 - brain imaging studies of, 458
 - cross-modal integration modulated by, 819, 820–827
 - effects on normal visual-tactile spatial interference of, 825–827
 - effects on spatial nature of cross-modal extinction of, 820–825
 - molecular processes in, 457–458
- Top-down influences, in synesthesia, 872–873
- Total communication (TC), audiovisual speech perception with, 755, 757–758, 763–765
- Total dominance model, of multisensory texture perception, 118
- Touch
 - cross-modal dynamic capture across audition, vision, and, 60–64
 - cross-modal extinction between mirror reflections and, 831–832
 - cross-modal interference between mirror reflections and, 828–831
 - cross-modal links with
 - in endogenous spatial attention, 552–554, 559–561
 - in exogenous spatial attention, 558
- TPJ. *See* Temporoparietal junction (TPJ)
- Tpt (temporoparietal association cortex),
 - in audiovisual convergence, 483, 484
- Trace learning, in rats, 674
- Training, in odor-taste learning, 77–78
- Trajectory, 402
- Transcranial magnetic stimulation (TMS)
 - for evaluation of visual cortex in tactile perception, 703–704, 707, 712, 715, 716
 - of selectivity in audiovisual affect pairing, 590, 591
- Transmodal gateways, 210–211, 217, 217

- Transverse temporal gyrus
activation by visual stimuli of, 778
in auditory speech pathway, 211, 212
- Trimodal neurons, 343
in premotor cortex, 247
in superior colliculus, 246
- Trimodal stimulus, test of separate
activation model with,
398–399, 400
- Tropical wandering spider, multisensory
signals in, 232
- Turn-and-reach movements, self-
generated Coriolis forces
during, 416
- TWIN (time-window-of-integration)
model, of response time,
403–407
- Two-dimensional tactile forms, visual
cortex in mental rotation of,
704–705, 706
- Two-layer connectionist model, of
multisensory texture perception,
119–120
- Two-point discrimination tests, 715
- U
- Umami, 314
- Ungulates, multisensory signals in, 227
- Unilateral neglect syndrome, 453
- Unimodal cortex, multisensory
neurons in
contribution of local inputs to,
348–352
correspondence with organization of
external inputs of, 344–348
- Unimodal stimulation, differential effects
of multimodal and, 646–648
- Unitization, in odor-taste learning, 79
- Unreliable-signal hypothesis, 236
- Use-dependent plasticity, 736
- V
- V6A area, 426, 433–434
- VAE. *See* Ventriloquism aftereffect (VAE)
- Vectorview neuromagnetometer, 516
- Ventral intraparietal area (VIP)
anatomical location and functional
properties of, 426, 430
in audiovisual convergence, 483, 484
connections to, 287
in control of defensive movements, 443,
444, 448–449
cortex of, 286
and deficits related to peripersonal
space, 432
multisensory convergence in, 296, 305
representations of face in, 807
role of multisensory integration in,
430–431
in spatial concordance, 492
- Ventral pathway, to temporal lobe, 126
- Ventral posterior nucleus (VP),
histological tracing of
multisensory pathways in, 365,
366, 368
- Ventral premotor (PMv) zone
in control of defensive movements, 443,
444–447
multisensory responses of, 289
- Ventral somatosensory (VS) area,
multisensory convergence in,
287, 298, 299–300
- Ventriloquism aftereffect (VAE), 40–42
cognitive strategies in, 143
experiments in nonhuman primates
on, 42–45
functional implications of, 45–47
persistence of, 45
spatial disparity and, 45
in unimodal condition, 46–47
- Ventriloquism aftereffect (VAE) ratio,
43–44
- Ventriloquism effect, 35–47, 142–146
cognitive strategies in, 143
cross-modal selective attention in, 89
defined, 36, 142
dominance of vision in, 27, 28
examples of, 36
functional implications of, 45–47
hemodynamic studies of, 491
measurement of, 142
model of neural substrate of
polysensory integration
in, 36–38
with movement, 49, 55–57
odor-taste synesthesia *vs.*, 73
parameters necessary for, 36
perceptual level in, 142–146
as pre-attentive phenomenon, 146
response reversals in, 143
spatial disparity in, 36
staircase procedure for, 58,
143, 144–145
standard explanation of, 142
strategic or cognitive factors in, 142
Stroop task interference and, 142
temporal and spatial dependency of,
39–40, 41–42
visual distracter in
attention to, 144–145
ignoring of, 142–143
not conscious seeing of, 145–146
with visual neglect, 145–146
- Ventrobasal complex, in somesthesia, 245
- VEPs (visual-evoked potentials), auditory-
visual interactions in, 30, 31
- Verbalism, of language function in blind
people, 727
- Verbal mediation, in object recognition,
134–135
- Vernier acuity, 36–37
- Vertical linear oscillation, 417–419, 422
- Vestibular system, in postural control,
785, 786
- Vestibulocollic reflexes, 414
- Vestibulospinal reflexes, effect of
gravito-inertial force on, 409–410
- Vibrotactile activation, of auditory
cortex, 777
- Video primacy effect, 233
- View dependency
in object recognition, 130–131
in scene recognition, 133–134
- Viewing distance, in audiovisual speech,
178, 179–181
- VIP. *See* Ventral intraparietal area (VIP)
- Virtual body effect, 825
- Visceral representation, of affective value
of stimuli, neuroimaging
studies of, 570
- Visible speech. *See* Lipreading
- Vision
alteration by sound of
in motion perception, 29
other aspects of, 28
in temporal aspects, 27–28
alteration of other modalities by, 27
cross-modal dynamic capture across
audition, touch, and, 60–64
development of cortical networks
for, 681–683
- Vision:place, audition:manner (VPAM)
hypothesis, 750
- Visual agnosia
and object recognition, 126–127
recognition of facial expressions in,
590–591
- Visual apparent motion, 50–52, 54–57
- Visual association areas, in visual speech
pathway, 213
- Visual-auditory convergence, in vitro
study of, 607–609
- Visual-auditory focused attention task,
test of separate activation model
in, 398, 399
- Visual bias, in ventriloquism effect,
144–145
- Visual calibration, of auditory space map,
614–616
- Visual capture, 36, 129
- Visual cortex
activation in blind subjects of,
124, 125
auditory-visual interactions in, 30–32
compensatory plasticity of, 738
connection of auditory cortex with,
285–287
cross-modal processing in, 124
remapping of cross-modal interactions
in, 544
simple cells of, 250, 251
in tactile discrimination, 30–31
in tactile object recognition, 124–127
in tactile perception, 703–708
with blindness, 711–716
of grating orientation, 703–704
for mental rotation of two-
dimensional form, 704–706
of motion, 706
of three-dimensional forms, 706
in visual speech pathway, 213
- Visual cues, in auditory spatial
representations, 731–734
- Visual deprivation
anterior ectosylvian cortex with,
696–697
auditory behavior with, 695–696

- cross-modal consequences
 - of, 695–699
 - Visual discrimination reversal, in
 - orbitofrontal cortex, 316, 317–318
 - Visual distracter, in ventriloquism effect
 - attention to, 144–145
 - ignoring of, 142–143
 - not conscious seeing of, 145–146
 - Visual dominance
 - cross-modal interactions with, 507–508, 510
 - in multisensory integration of dynamic events, 62–64
 - over proprioception, in cross-modal modulation, 805
 - Visual edges, 125
 - Visual emotion, cross-modal integration
 - of auditory and, 572
 - Visual-evoked potentials (VEPs), auditory-visual interactions in, 30, 31
 - Visual experience, altered, auditory consequences of, 604–605, 606
 - Visual fixation
 - multisensory integration with, 384–386, 389–390
 - superior colliculus in, 374
 - Visual hypothesis, of action
 - understanding, 454
 - Visual imagery
 - magnetoencephalography of, 522
 - synesthesia and, 873–874
 - in tactile perception, 707
 - Visual information processing, in
 - audiovisual speech perception, 179–184, 180, 181
 - Visual input(s)
 - encoding of, 377
 - to orbitofrontal cortex, 316–318
 - in postural control, 785, 786
 - routing to auditory pathway of, 683–685
 - Visual instruction, of auditory space map
 - in midbrain, 613–623
 - Visual localization, errors in, 411–412
 - Visual masking, of inducing stimuli, in
 - color-graphemic synesthesia, 853–856
 - Visual modulation, of tactile perception, 802–805
 - with fake hand, 805–807, 825
 - near face, 807–809
 - Visual neglect
 - bimodal stimulation for, 811–812
 - as probe for investigating auditory-visual interactions, 810
 - ventriloquism effect with, 145–146
 - Visual networks, in auditory cortex, 685–686, 687, 688
 - Visual perception
 - with deafness, 725–726
 - enhancement through bimodal stimulation of contralesional, 811–812
 - modulations by sound of, 27–32
 - Visual position, pitch and, 91
 - Visual processing, cross-modal links with
 - in endogenous spatial attention, 550–553, 559–561
 - in exogenous spatial attention, 557–558
 - Visual projection, to anterior ectosylvian sulcus, 345
 - Visual receptive field, in tool use, 455–456
 - Visual reference frames, 463
 - Visual reinforcers, amygdala responses to, 571–572
 - Visual resolution, in audiovisual speech perception, 181–182
 - Visual response properties, in superior colliculus, maturation of, 628–629
 - Visual responsiveness, in auditory
 - thalamus and cortex, 659
 - Visual search task, attention in, 326–328
 - Visual sensory-specific satiety, 318–320
 - Visual signals, in shaping of auditory responses, 605–607
 - Visual space map(s), 613, 614, 731
 - aligning auditory and, 599–610, 621
 - Visual speech pathway, 211, 213–214
 - Visual speech perception. *See* Lipreading
 - Visual stimulation, vertical linear oscillation and, 417–419
 - Visual stimuli
 - activation of auditory cortex by, 778–779
 - activation of orbitofrontal cortex by, 570–572
 - flicker-fusion threshold of, 38
 - representation of pleasantness of, 318–320
 - Visual structure, auditory “capture”
 - of, 28–29
 - Visual system, spatial acuity in, 36–37
 - Visual-tactile-auditory neurons, in
 - polysensory zone of precentral gyrus, 446, 447
 - Visual-tactile extinction
 - cross-modal, 802–805, 826, 827, 828–829
 - effects of tool use on spatial nature of, 820–825
 - Visual-tactile integration, 107–111, 113–115
 - modulated by mirrors, 828–832, 833
 - modulated by tool use, 819, 820–827, 833
 - spatial nature of, 825–827
 - Visual-tactile interaction, in focused attention, 405–406
 - Visual-tactile neurons, in polysensory zone of precentral gyrus, 445–446
 - Visual-tactile object recognition, 123–136
 - behavioral correlates of, 127–130
 - experimental studies on, 130–135
 - for multiple objects, 132–135
 - for single objects, 130–132
 - neuronal correlates of, 124–127
 - temporal constraints on, 136
 - Visual-tactile spatial interference, effects
 - of tool use on, 825–827
 - Visual target processing, effect of auditory cues on, 19, 20
 - Visual-to-taste convergence, 311, 316–318
 - Visual-vestibular illusions, 244
 - Visual Wulst area, 647
 - Visuomotor transformations, 543
 - Visuotactile integration,
 - magnetoencephalography of, 519
 - Visuotactile interactions, near face, 807–809
 - Visuotactile processing, reference system in, 808–809
 - Vocal expression, of emotion, 165, 582–584
 - Vocal gestures
 - evidence for perception of, 192–194
 - recognition by infants of, 191–192
 - Vocal imitation, by infants, 191
 - Vocal tract, acoustic transfer function of, 206
 - Vocal tract motion, in audiovisual speech perception, 184, 185
 - Voice
 - dynamic range of, 179
 - fundamental frequency of, 184
 - Voicing feature, in speech perception, 204n, 205
 - Vowels, description of differences among, 196–197
 - VP (ventral posterior nucleus),
 - histological tracing of multisensory pathways in, 365, 366, 368
 - VPAM (vision:place, audition:manner) hypothesis, 750
 - VS (ventral somatosensory) area,
 - multisensory convergence in, 287, 298, 299–300
- W
- Waiting time, 400
 - Warblers, multisensory processes in, 235, 236
 - Warning effect, 379
 - Warning sound, for visual neglect, 812
 - Weighted average models, of multisensory texture perception, 119
 - Wernicke’s area
 - in audiovisual speech perception, 217
 - in auditory speech, 211, 212
 - response depression in, 511
 - in sign language processing, 777–778
 - “What” pathway, 126
 - “Where” pathway, 126
 - Window of integration, 403
 - Within-compound associations, in odor-taste learning, 79
 - Wolf spiders, multisensory signals in, 228, 233
 - Wood warblers, multisensory processes in, 236
 - Wulst area, 647