

Index

- Abelson, Robert, 9
- Accent shape parameter, 188, 190
- Activation with a group, 137
- Activation level, 46, 63, 117–118
- Activation map, computing, 67–68
- Activation threshold, 46, 118
- Active behaviors, 114
- Adjustment parameters, 137–138
- Adultomorphism, 30
- Aesthetics, 51–52, 85
- Affect Editor* (Janet Cahn), 186
- Affect space, 165, 169
- Affective appraisals, 115–116
- Affective assessment subsystem, 95
- Affective feedback, 33–34
- Affective influence, 138
- Affective intent
 - classifying
 - method, 87–93
 - performance, 93–94
 - cross-cultural studies on, 81–82
 - design issues, 85–87
 - drives and, 110
 - in human speech, 81–82
 - human-robot communication and, 98–99
 - mirroring, 101
 - recognizing, 85–87
 - socio-emotional context and, 97
- Affective Reasoner, 238
- Affective responses, 36
- Affective state, 114
- Agendas, balancing, 34
- AI reasoning systems, 9, 238
- Aibo (robot dog), 24
- Aldiss, Brian, 1
- ALIVE project, 21
- Andrew (science fiction android), 240
- Anger, 169, 171, 200–203
- Anima machina, challenge of creating, 235–236
- Animated pets, 2–3, 10–11, 242. *See also specific names*
- Animation insights, 163–165, 204
- Appeal of social robots, 51
- Appetitive behavior, 131
- Applications of sociable robots, 1–4
- Appraisals
 - affective, 115–116
 - cognitive, 124
- Approval-attention releaser, 93, 114
- Arousal, regulating, 34, 167–168
- Arousal tag, 95–96
- Articulation, 56, 193
- Artificial Intelligence Lab (at MIT), 5, 23
- Asimo (child-sized humanoid robot), 4
- Asimov, Isaac, 1, 240
- Assertiveness setting, 191
- Attend to human’s speech turn, 145
- Attention
 - activation map, computing, 67–68
 - directing, 33
 - socially manipulating, 74–77
 - visual, 215–217
- Attention system
 - design issues, 61–69
 - attention activation map, 67–68
 - bottom-up contributions, 63–65
 - eye movement, 68
 - habituation effects, 62–63, 68–69
 - overview, 61–63
 - top-down contributions, 64–67
 - evaluation criteria, 72–77
 - gain adjustment on looking preference, 74
 - gain adjustment on saliency, 72–74
 - overview, 72
 - socially manipulating attention, 74–77
 - eye movement and, 68, 218–220
 - function of, 44–45, 61, 79–80
 - habituation effects and, 62–63, 68–69
 - limitations and extensions, 77–78
 - post-attentive processing, 69–72
 - eye detection, 69–70
 - loom detection, 71–72
 - oculo-motor system and, 218
 - overview, 69
 - proximity estimation, 71
 - threat detection, 72
 - stages of, 62
- Attentional activity space, 172
- Attentive-regard behavior, 144
- Audience perception, 52
- Auditory system
 - affective intent and
 - classifying, 87–94
 - cross-cultural studies on, 81–82
 - design issues, 85–87
 - in human speech, 81–82
 - human-robot communication and, 98–99
 - mirroring, 101
 - recognizing, 85–87
 - socio-emotional context and, 97
 - emotion system and, integrating, 94–97
 - hardware design and, 55
 - infant-directed speech and, 82–84
 - limitations and extensions, 101–103
 - low-level perception and, 59–60
 - overview, 81
 - results from studies on, 100–101

- Autobiographic agent, 238
- Autobiographic memory, 10, 238
- Autonomy, 8
- Average pitch parameter, 188, 190
- Average-pitch setting, 190
- Avoid-people behavior, 66, 72, 74
- Avoid-stimulus behavior, 141
- Avoid-toys behavior, 66, 72
- Avoidance behaviors, 66, 72, 74, 141

- Ball, Gene, 22
- Baseline-fall setting, 190–191
- Basic computational unit, 46
- Basic emotions, 106–107. *See also specific types*
- Basis postures, 167–168
- Bates, Joseph, 22
- Bateson, Mary Catherine, 33
- BDI approach, 9
- Behavior centers, 131–132, 134
- Behavior groups, 130–131, 135
- Behavior level of motor behavior, 146–147
- Behavior model, 135–136
- Behavior system
 - adjustment parameters, 137–138
 - affective appraisal and, 116
 - ethology and, 128–132
 - behavior groups, 130–131, 135
 - behavior hierarchies, 131–132
 - behaviors, 129
 - motivational contributions, 130
 - overview, 128–129
 - perceptual contributions, 129–130
 - function of, 45–46
 - hierarchy of
 - concept of, 131–132
 - environmental-regulation level, 140–141
 - functional level, 139–140
 - play behaviors, 143–145
 - protective behaviors, 141–143
 - infant-caregiver interactions and, 127–128
 - interaction levels, 146–147
 - internal measures, 136
 - of Kismet
 - organization of, 132–138
 - proto-social responses of, 139–145
 - limitations and extensions, 154–156
 - motivation system and, 130
 - motor system and, 145–150
 - overview, 127, 145–150
 - perceptual system and, 129–130
 - playful interactions with Kismet and, 150–154
 - releasers, 45, 136–137
- Behavior-driven contributions, 65–67
- Behavioral homeostasis, 106

- Behavioral response threshold level, 118
- Behaviors, view of, 129
- Being there component, 7
- Being understood component, 10–11, 239–240
- Believability, 8, 10, 41, 51–52, 158, 233
- Bicentennial Man* (short story), 240
- Billard, Aude, 11
- Blade Runner* (film), 1
- Blumberg, Bruce, 41, 46, 123, 129, 132, 134
- Bottom-up contributions, 63–65, 78
- Brazelton, T. Barry, 27–29
- Breathiness parameter, 188, 193
- Breathiness setting, 193
- Breese, Jack, 22
- Brilliance parameter, 188, 193
- Brooks, Rodney, 7, 46
- Brothers, Leslie, 237–238
- Bruner, Jerome, 9
- Burst-pause-burst pattern, 28

- C-3PO (science fiction mechanical droid), 1, 240
- Cahn, Janet, 186–187, 208–209
- Call-to-person behavior, 138, 143–144
- Carnegie Mellon University (CMU), 22
- Cassell, Justine, 19, 238
- CCD (charge coupled device) camera, 54
- Challenges of building sociable robots
 - design issues, 230–233
 - learning, 16, 233–235
 - overview, 229–230
 - reflections and dreams about, 241–242
 - socially situated learning infrastructure, 233–235, 239
 - ultimate, 235–241
 - anima machina, 235–236
 - autobiographic memory, 238
 - embodied discourse, 236–237
 - empathy, 237–238
 - evaluation metrics, 239
 - friendship, 240
 - overview, 235
 - personal recognition, 237
 - personality, 236
 - personhood, 240–241
 - socially situated learning, 239
 - theory of mind, 237
 - understanding human, 239–240
- Charge coupled device (CCD) camera, 54
- Classification of affective intent
 - method, 87–93
 - performance, 93–94
- CMU (Carnegie Mellon University), 22
- Cog (humanoid robot), 23
- Cognitive appraisals, 124

- Coherence, 157
- Collis, Glyn, 31
- Color saliency feature maps, 63–64, 78
- Comma-pause setting, 192
- Common currency, 47–48
- Communication development, 30–31. *See also*
Vocalization system
- Competent behavior in complex world, exhibiting, 41,
232–233
- Componential approaches, 170–172
- Consummatory behavior, 131
- Container nodes, 134
- Contingency, 35
- Conversation agents, embodied, 7, 20–21
- Conversation pragmatics, 30–31
- Cosmo (animated Web-based pedagogical agent
for children), 20–21
- Cyber-pets, 2–3, 10–11, 242. *See also specific names*
- Darwin, Charles, 111
- Dautenhahn, Kerstin, 6, 9–11, 24, 237–238
- David (science fiction robot), 1
- DB (full-bodied humanoid), 23
- Deactivation within a group, 137
- DEC (Digital Equipment Corporation), 56
- DECTalk3, 186–187
- DECTalk synthesizer settings, 189–195
- DECTalk v.4.5 (software), 56
- Deliver speech turn, 145
- Depth map, 77–78
- Design issues for sociable robots
aesthetics, 51–52, 85
affective intent, recognizing, 85–87
attention system, 61–69
attention activation map, 67–68
bottom-up contributions, 63–65
eye movement, 68
habituation effects, 62–63, 68–69
overview, 61–63
top-down contributions, 65–67
challenges of building social robots and, 230–233
ethology and, 42–43
evaluation criteria, 48–49
expressive vocalization system, 185–186
facial animation system, 157–158
hardware, 52–60
auditory system, 55
motor system, expressive, 55–56
overview, 52–53, 60
perceptual system, 57–60
vision system, 54–55
vocalization system, 56–57
of Kismet, 39–41
lip synchronization, 185–186
overview, 39–41
synthetic nervous system and
framework, 43–46
of Kismet, 42–43, 94–95
mechanics of, 46–48
term of, 39
vision system, 61–69
attention activation map, 67–68
bottom-up contributions, 63–65
eye movement, 68
habituation effects, 62–63, 68–69
overview, 61–63
top-down contributions, 65–67
visual-motor system, 213–215
vocalization system, 85–87
- Developmental psychology insights
communication development, 30–31
infant-caregiver interactions, 27–29
Kismet and, 27, 36–37
proto-social responses for, 36–37
social learning, 31–36
- Diamond Age, The* (Stephenson), 4
- Dick, Philip, 1
- Digital Equipment Corporation (DEC), 56
- Digital pets, 2–3, 10–11, 242. *See also specific names*
- Disengagement phase of infant-caregiver interactions,
37, 128
- Disgust, 143, 168–169, 201–203
- Distress, 143
- Do Androids Dream of Electric Sheep?* (Dick), 1
- Dobbs, Darris, 208
- Dolls, robotic, 2–3
- Drives
affective intent and, 110
affective appraisal and, 116
emotional releasers and, 114
extension to, 123–124
fatigue, 109–110, 117, 122, 140
social, 72, 109, 136, 140
- Edge orientation, 78
- Edsinger, Aaron, 69–70
- Eibl-Eibesfeldt baby scheme, 230
- Ekman, Paul, 111, 173
- Ekman six, 96, 107, 111
- Elliot, Clark, 238
- Embodied approach, 9–10
- Embodied discourse, challenging of creating, 236–237
- Embodied systems
importance of, 7
interface with humans and, 19–25
conversation agents, 7, 20–21
humanoids, human-friendly, 22–23
interactive characters, 21–22

- Embodied systems (cont.)
 - overview, 19
 - personal robots, 24–25
- Emergent scaffolding, 32
- Emotion. *See also specific type*
 - components of, 112–114
 - processes, 165
- Emotion arbitration subsystem, 96, 118–119
- Emotion elicitor stage, 96, 116–117
- Emotion system
 - activation level and, 117–118
 - affective appraisal and, 115–116
 - affective subsystem of, 95
 - appraisal system and, 106, 115–116
 - auditory system and, integrating, 94–97
 - basic emotions and, 106–107
 - components of emotion and, 112–114
 - Ekman six and, 96, 107, 111
 - emotion arbitration subsystem of, 96, 118–119
 - emotional elicitor stage and, 96, 116–117
 - extension to, 124–125
 - of Kismet, 94–97, 107, 124–125
 - in living systems, 105–107
 - negative emotions in, 106
 - overview, 110–111
 - personality and, 124–125
 - positive emotions in, 106
 - releasers and, 94–95, 114–115
 - relevance-detection system and, 106
 - response-preparation system and, 106
 - responses and, 111–112
 - secondary emotions and, 124
 - somatic marker process and, 95–97, 115
- Emotive facial expression
 - generating, 165–170
 - subsystem, 161–163
- Empathy, 9, 237–238
- Engage-people behavior, 66, 141
- Engage-toys behavior, 66, 137–138, 140–141, 221
- Engagement behaviors, 66, 137–138, 140–141, 221
- Engagement, inferring level of, 225
- Entrainment by infant, 35
- Environment-regulation level of behavior, 140–141
- Ethology
 - behavior system and, 128–132
 - behavior groups, 130–131, 165
 - behavior hierarchies, 131–132
 - behaviors, 129
 - motivational contributions, 130
 - overview, 128–129
 - perceptual contributions, 129–130
 - design issues for sociable robots and, 42–43
- Evaluation criteria
 - attention system, 72–77
 - gain adjustment on looking preference, 74
 - gain adjustment on saliency, 72–74
 - socially manipulating attention, 74–77
 - design issues for sociable robots, 48–49
 - facial animation system, 180–182
 - vision system, 72–77
 - gain adjustment on looking preference, 74
 - gain adjustment on saliency, 72–74
 - socially manipulating attention, 74–77
- Evaluation metrics, challenge of, 239
- Exaggeration parameter, 188
- Exploratory responses, 36
- Expression threshold level, 118
- Expressive feedback, 86
- Expressive speech, 185
- Expressive versatility, 158
- Expressive vocalization system. *See also*
 - Vocalization system
 - design issues, 185–186
 - emotions in human speech and, 186–187
 - expressive voice synthesis and, 187–197
 - articulation, 193
 - overview, 187–190
 - pitch parameters, 188, 190–192
 - timing parameters, 188, 192
 - voice-quality, 188, 192–193
 - generating utterances, 194–198, 209
 - implementation overview, 194
 - of Kismet, 147, 185–186, 195–203
 - limitations and extensions, 208–210
 - mapping vocal affect parameters to synthesizer settings, 194–195
 - real-time lip synchronization and facial animation and, 203–208
- Expressive voice synthesis, 187–193
- Extraction system, low-level, 44
- Eye detection, 69–70
- Eye movement
 - attention system and, 68, 218–220
 - human, 211–213
 - oculo-motor system and, 218–220
 - similar, 215
- Face control, levels of
 - facial function layer, 161–163
 - motor demon layer, 158–159
 - motor primitives layer, 159–160
 - motor server layer, 160–161
 - overview, 158
- Face-to-face interaction, 144
- Facial action coding system (FACS), 173–175

- Facial animation system
 - design issues, 157–158
 - evaluation criteria, 180–182
 - face control levels and, 158–163
 - facial function layer, 161–163
 - motor demon layer, 158–159
 - motor primitives layer, 159–160
 - motor server layer, 160–161
 - overview, 158
 - generation of facial expressions and, 163–172
 - animation insights, 163–165
 - comparison to componential approaches, 170–172
 - emotive expression, 165–170
 - overview, 163
 - of Kismet, 147, 172–179
 - limitations and extensions, 182–183
 - lip synchronization and, real-time, 203–208
 - overview, 157
- Facial display and behavior, communicative, 161–163
- Facial expressions
 - analysis of, 173–179
 - generating, 163–172
 - animation insights, 163–165
 - comparison to componential approaches, 170–172
 - emotive expression, 165–170
 - overview, 163
 - infant-directed speech and, 84
 - of Kismet, 165–170
 - line drawings of, 175–179
 - mirroring, 28
- Facial function layer, 161–163
- Facial measurement system, 173–175
- FACS (facial action coding system), 173–175
- FAPs (fixed action pattern), 149–150
- Fatigue drive, 109–110, 117, 122, 140
- Fear, 169, 171, 200–203
- Feature maps
 - color saliency, 63–64, 78
 - computing, 63–65
 - edge orientation and, 78
 - habituation, 78
 - motion saliency, 64
 - skin tone, 64–67
- Feedback
 - affective, 33–34
 - expressive, 86
 - instructional, 18–19
- Fernald, Ann, 82–84, 88, 92–93
- Field of View (FoV) cameras, 69
- Final lowering parameter, 188, 190–191
- Finite state machine (FSM), 149–150, 220
- Fixed action pattern (FAP), 149–150
- Fleming, Bill, 208
- Foerst, Anne, 241
- Found-toy behavior, 137
- Foveate vision, 211–212
- Friendship, challenge of creating, 240
- Friesen, Wallace, 173
- Frijda, Nico, 106
- Frustration, internal measure of, 136
- FSM (finite state machine), 149–150, 220
- Functional level of behavior, 139–140
- Gain adjustment
 - on looking preference, 74
 - on saliency, 72–74
- Gain-of-aspiration setting, 193
- Gain-of-friction setting, 193
- Gain-of-voicing setting, 193
- Games, establishing, 35–36
- Gandalf (precursor system of Rea), 21
- Glass, Jim, 59
- Glos, Jennifer, 238
- Goal directedness, 115
- Goal releaser, 136
- Graphical systems, 21
- Greet-person behavior, 138, 144
- Greeting phase of infant-caregiver interactions, 37, 128
- Groups
 - activation within, 137
 - deactivation within, 137
 - temporal dynamics within, 137–138
- Guided Search v2.0 (software), 61
- Habituation effects, 62–63, 68–69
- Habituation feature maps, 78
- Habituation filter, 68–69
- Halliday, M. A. K., 31, 185
- Happiness, expression of, 201–203
- Hardware design. *See* Design issues for sociable robots
- Hat-rise setting, 191
- HCI (human computer interaction), 15–16
- Health-related robotic technology, 4
- Hendriks-Jansen, Horst, 32
- Hetherington, Lee, 59
- Hierarchy of behavior system
 - concept of, 131–132
 - environmental-regulation level, 140–141
 - functional level, 139–140
 - play behaviors, 143–145
 - protective behaviors, 141–143
- Homeostatic regime, 108–109
- Homeostatic regulation, 105, 107–110
- Household robots, 4

- Human computer interaction (HCI), 15–16
- Human listener experiments, 201–203
- Human speech
- affective intent in, 81–82
 - analysis of, 198–201
 - emotion in, 186–187
 - expressive, 185
 - infant-directed, 82–84
 - maternal exaggeration and intonation in, 82–84
 - perceptual system and, 145
 - as saliency marker, 86
 - as training signal, 85
- Human visual behavior, 211–213
- Human-aware component, 8–10
- Humanoids, human-friendly, 22–23
- Hydraulic model, 47
- iCybie (robotic dog), 24
- Imitation, maximizing, minimizing and modulating, 34
- Infant-caregiver interactions
- behavior system and, 127–128
 - developmental psychology insights and, 27–29
 - Kismet and, 16
 - phases of, 37, 127–128
- Infant-directed human speech, 82–84
- Initiation phase of infant-caregiver interaction, 37, 127
- Instruction, quality, 234
- Instructional feedback, 18–19
- Intensity of stimulus, 115
- Interact-ability criteria, 49
- Interaction. *See also* Infant-caregiver interactions
- distance, luring people to good, 224–225
 - dynamics of, 36–37
 - face-to-face, 144
 - infant-caregiver
 - behavior system and, 127–128
 - developmental psychology insights and, 27–28
 - Kismet and, 16
 - phases of, 37, 127–128
 - levels, 146–147
 - perception and, 8–9
 - playful
 - dynamics of, 151–153
 - infant-caregiver, 29, 35
 - with Kismet, 150–154
 - regulating, 119–123, 150–151
 - vocal exchanges and, 153–154
 - regulation of, 40, 231–232
 - self-motivated, 40, 231
 - social, 16–17, 37, 40, 221–223
 - understanding and, 8, 10–11
 - visual behavior and, 221–223
- Interactive approach, 9–10
- Interactive characters, 21–22
- Interface of robots with humans
- embodied systems that interact with humans and, 19–25
 - conversation agents, 7, 20–21
 - humanoids, human-friendly, 22–23
 - interactive characters, 21–22
 - overview, 19
 - personal robots, 24–25
 - human computer interaction and, 15–16
 - socially situated learning and, 16–19
- Internal scaffolding, 32
- Intrinsic pleasantness, 115
- Intrinsic properties, 17
- Izard, Carroll, 111
- Johnson, Lewis, 28
- K-lines, 47
- Kaye, Kenneth, 30, 34–36
- Kinny, David, 9
- Kismet (sociable robot). *See also specific systems of*
- aesthetics of, 51–52
 - behavior system of
 - organization of, 132–138
 - proto-social responses and, 139–145
 - creation of, 5–6
 - design issues of, 39–41
 - developmental psychology insights and, 27, 36–37
 - proto-social responses and, 36–37
 - ear movements of, 174–176
 - emotion system of, 94–97, 107, 124–125
 - expressive vocalization system of, 147, 185–186, 195–203
 - eye detection system for, 69–70
 - eyebrow movements of, 174–175
 - eyelid movements of, 174–175
 - facial animation system of, 147, 172–179
 - facial expressions of, 165–170
 - hardware design of
 - auditory system, 55
 - motor system, expressive, 55–56
 - overview, 52–53, 60
 - perceptual system, 57–60
 - vision system, 54–55
 - vocalization system, 56–57
 - homeostatic regulation system of, 107–110
 - infant-caregiver interactions and, 16
 - interact-ability criteria, 49
 - loom detection of, 71–72
 - motor system of, 146–150
 - oculo-motor system of, 147, 216–220
 - overview, 11–13
 - playful interactions with, 150–154

- proto-social responses of
 - behavior system and, 139–145
 - developmental psychology insights and, 36–37
 - social intelligence components of, 6–11
 - being there, 7
 - being understood, 10–11
 - human-aware, 8–10
 - life-like quality, 7–8
 - socially situated learning, 11
 - somatic marker process of, 95–97
 - synthetic nervous system of, 42–43, 94–95
 - threat detection of, 72
 - vision of sociable robots and, 5–6
- Klatt articulation synthesizer, 56
- Knowing what actions to try, learning, 18
- Knowing what matters, learning, 17, 233

- Laryngealization parameter, 188, 193
- Laryngealization setting, 193
- Lax-breathiness setting, 193
- Learning. *See also* Socially situated learning
 - challenges of building sociable robots and, 16, 233–235
 - developmental psychology insights and social, 31–36
 - environment, 16–17
 - instructional feedback and, 18–19
 - knowing what actions to try and, 18
 - knowing what matters and, 17, 233
 - quality instruction and, 234
 - scaffolding for social, 31–36
 - structured, 234
- Level of interest of behavior, 136
- Levenson, Robert, 106
- Levergood, Thomas, 204
- Life-like quality component, 7–8, 235–236
- Limited capacity stage, 62
- Line drawings of facial expressions, 175–179
- Lip synchronization
 - design issues, 185–186
 - facial emphasis and, 161–163
 - improvements to, 209–210
 - real-time, 203–208
- Loom detection, 71–72
- Lorenz, Konrad, 45, 47–48, 129
- Loudness parameter, 188, 193
- Lt. Commander Data (android), 1

- McFarland, David, 47–48
- Madsen, Frank, 204
- Maes, Pattie, 46
- Mapping vocal affect parameters to synthesizer settings, 194–195
- Massachusetts Institute of Technology. *See* MIT
- Mastery/curiosity drive, 123

- Media Lab (at MIT), 20–22, 236
- Memory
 - autobiographic, 10, 238
 - spreading activation and, 47
- Memory mode, 204
- Minsky, Marvin, 46–47
- Mirroring
 - affective, 101
 - facial expressions, 28
- MIT (Massachusetts Institute of Technology)
 - Artificial Intelligence Lab, 5, 23
 - Media Lab, 20–22, 236
 - Spoken Language Systems Group, 55, 59
- Motherese, 29
- Motion saliency feature maps, 64
- Motivation system
 - behavior system and, 130
 - emotion system and, 110–119
 - affective appraisal and, 115–116
 - components of emotion and, 112–114
 - emotion activation and, 117–118
 - emotion arbitration and, 96, 118–119
 - emotional elicitors and, 96, 116–117
 - in living systems, 105–107
 - overview, 110–111
 - releasers and, 94–95, 114–115
 - responses, 111–112
 - function of, 45
 - homeostatic regulation and, 105, 107–110
 - limitations and extensions, 123–125
 - in living systems, 105–107
 - overview, 105
 - playful interactions and, regulating, 119–123
 - term of, 105
- Motor demon layer, 158–159
- Motor primitives layer, 159–160
- Motor server layer, 160–161
- Motor skills mechanisms, 148–150
- Motor skills system, 148
- Motor system. *See also* Expressive vocal system; Facial animation system; Oculo-motor system
 - behavior system and, 145–150
 - function of, 46
 - hardware design, expressive, 55–56
 - of Kismet, 146–150
 - overview of, 145–150
- MOVAID system, 24
- Mutual orientation phase of infant-caregiver interactions, 37, 127
- My Real Baby (robotic doll), 3

- Nagao, Katashi, 21
- NASA (National Aeronautics and Space Administration), 23

- Nass, Clifford, 15–16, 52
 National Aeronautics and Space Administration (NASA), 23
 Natural systems. *See* Ethology
 Negative emotions, 106. *See also specific types*
 Nelson, Katherine, 10
 Network of units, 47
 Neutral-speech releaser, 92, 114
 Newson, John, 27–28, 30, 61
- Oculo-motor system
 extensions, 226
 eye movement and, 218–220
 of Kismet, 147, 216–220
 low-level visual perception and, 216
 overview, 216
 post-attentive processing and, 218
 vision-motor system and, 216–220
 visual attention and, 216–217
 Opto-kinetic nystagmus (OKN), 213, 215
 Overwhelmed regime, 109
 Oz project, 22
- P3 (adult-sized humanoid robot), 4, 23
 Parentese, 29
 Pause discontinuity parameter, 188, 193
 Pauses parameter, 188
 Peedy (animated parrot), 22
 People-present releaser, 140
 Pepperberg, Irene, 33
 Perception
 audience, 52
 high-level, 56–57
 interaction and, 8–9
 knowing what matters and, 17
 low-level, 59–60
 states, 115
 Perceptual releasers, 129–130
 Perceptual system
 behavior system and, 129–130
 emotional releasers and, 115
 function of, 45
 hardware design and, 57–60
 human speech and, 145
 Personal agency/control space, 172
 Personal recognition, challenge of, 237
 Personal robots, 24–25
 Personal space, establishing, 224
 Personality, 124–125, 236
 Personhood, challenge of creating, 240–241
 Petz (animated pet on computer screen), 24–25
 Physicality of sociable robots
 aesthetics, 51–52
 appeal, 51
 hardware design, 52–60
 auditory system, 55
 motor system, expressive, 55–56
 overview, 52–53
 perceptual system, 57–60
 vision system, 54–55
 vocalization system, 56–57
 Picard, Rosalind, 124, 186
 Pitch contour slope parameter, 188, 190
 Pitch discontinuity parameter, 188, 193
 Pitch parameters, 188, 190–192
 Pitch range parameter, 188, 191
 Pitch reference line parameter, 188, 191
 Pitch variance, 93
 Pitch-range setting, 191
 Play behaviors, 143–145
 Play-dialogue phase of infant-caregiver interactions, 37, 128
 Playful interactions
 dynamics of, 151–153
 infant-caregiver, 29, 35
 with Kismet, 150–154
 regulating, 119–123, 150–151
 vocal exchanges and, 153–154
 Pleasure-arousal space, 170–171
 Pleasure-displeasure space, 171–172
 Plutchik, Robert, 106, 111, 118
 Positive emotions, 106. *See also specific types*
 Post-attentive processing
 eye detection, 69–70
 loom detection, 71–72
 oculo-motor system and, 218
 overview, 69
 proximity estimation, 71
 threat detection, 72
 Pre-attentive stage, 62
 Precision, 193
 Prespeech movements, 28
 Primary prototype postures, 167–168
 Primer (science fiction interactive book), 4
 Primitive level of motor behavior, 146–147
 Progress, recognizing, 233–234
 Protective behaviors, 141–143
 Protective responses, 36
 Proto-dialogues, 29, 203, 231
 Proto-language, 31
 Proto-social responses
 of infants, 28
 of Kismet
 behavior system and, 139–145
 developmental psychology insights and, 36–37
 scaffolding and, 32
 Prototype postures, 167–168
 Proximity estimation, 71

- QNX machines, 204–206
 QNX real-time operating system, 55
 Quickness setting, 193
- R2-D2 (science fiction mechanical droid), 1, 4, 240
 Rea (synthetic real-estate agent), 20, 236
 Reacquire speaking turn, 145
 Readability, 10, 21, 40, 45, 158, 232
 Real-time performance, 39, 85, 230
 Real-time response, 157
 Realism, believability versus, 51–52
 Reeves, Byron, 15–16, 52
 Referencing, 33–34
 Reflexes, 29
 Regulation of interaction, 40, 231–232
 Regulatory responses, 36
 Reject behavior, 143
 Releasers
 affective appraisal and, 116
 approval-attention, 93, 114
 behavioral, 45, 136–137
 concept of, 45
 emotional, 94–95, 114–115
 goal, 136
 neutral-speech, 92, 114
 people-present, 140
 perceptual, 129–130
 process, 114–115
 soothing-speech, 92, 114
 specificity of, 137
 threat-stimulus, 142
 toy-present, 140
 Relevance-detection system, 106
 Relevance of stimulus, 115
 Relinquish speaking turn, 144–145
 Repetition, introducing, 34–35
 Response-preparation system, 106
 Responses, emotional, 111–112
 Richness setting, 193
 Robbie (science fiction robot), 1
 Robita (upper-torso humanoid robot), 237
 Robonaut (humanoid robot), 23
 Russell, James, 113, 170–171
- Saccades, 212
 Sadness, 200–203
 Satiated-fatigue behavior, 139–140
 Satiated-social behavior, 139–140
 Satiated-stimulation behavior, 139–140
 Sato, Jun, 187
 Scaffolding for social learning, 31–36
 Scale factors (SF), 195
 Scassellati, Brian, 9
 Schaffer, Rudolph, 30
 Schank, Roger, 9
 Scherer, Klaus, 106–107, 130
 Science University of Tokyo, 22–23
 Scott, Heather, 171–172, 174
 Searching behaviors, 140
 Secondary emotions, 124
 Seek-people behavior, 66, 72, 74, 140
 Seek-toys behavior, 66, 72, 137–138, 140, 221
 Self-motivated interaction, 40, 231
 Self-stimulation drive, 123
 SF (scale factors), 195
 Shared reference, 33
 Siegel, Daniel, 31, 238
 Silas (animated dog), 21
 Situatedness of robot, 7
 Skill, term of, 148–149
 Skills level of motor behavior, 146–147
 Skin tone feature maps, 64–67
 SM (somatic marker) process, 95–97, 115
 Smith, Craig, 113, 171–172, 174
 Smooth pursuit vision, 213
 Smoothness setting, 193
 SNS. *See* Synthetic nervous system
 Social amplification, 222–225
 Social constraints on animate vision. *See* Visual-motor system
 Social cues, 40, 143, 232
 Social drive, 72, 109, 136, 140
 Social environment, 39
 Social expectations, establishing appropriate, 39–40, 230–231
 Social intelligence components. *See also specific sociable robots*
 being there, 7
 being understood, 10–11, 239–240
 human aware, 8–10
 life-like quality, 7–8, 235–236
 socially situated learning, 11
 Social interaction, 16–17, 37, 40, 221–223
 Social interaction hypothesis, 238
 Social level of motor behavior, 146–147
 Social referencing, 33–34
 Social responsiveness, improving, 226–227
 Socially situated learning
 challenges of, 233–235, 239
 as component of social intelligence and, 11
 infrastructure for, 233–235
 interface of robots with humans and, 16–19
 strategy, 11
 Socio-emotional context of affective intent, 97
 Somatic Marker Hypothesis, 95
 Somatic marker (SM) process, 95–97, 115
 Soothing-speech releaser, 92, 114
 Speaker-dependent vocalization systems, 86

- Speaker-independent vocalization systems, 86
 Speech rate parameter, 188, 192
 Speech. *See* Human speech; Vocalization system
 Spoken Language Systems Group (at MIT), 55, 59
 Spreading activation, 47
 Stance tag, 96
Star Trek (television series), 1, 240
Star Wars (film), 1, 240
 Stephenson, Neal, 4
 Stern, Daniel, 34
 Steve (tutoring system), 20
 Stimulation drive, 72, 109, 123–124, 140, 145
 Stimulus-driven contributions, 63–65, 78
 Story-based approach, 9
 Stress frequency parameter, 188, 192
 Stress-rise setting, 190, 193
 Subsystem of networks, 47
 Success, recognizing, 234
 Suckling behavior, 28
 Surprise, 201–203
Swamped, (interactive character), 22
 Synchrony, 157
 Synthetic character systems, 21–22
 Synthetic Characters Group, 22
 Synthetic nervous system (SNS)
 framework for, 43–46
 of Kismet, 42–43, 94–95
 mechanics of, 46–48
 term of, 39
- Takeuchi, Akikazu, 21
 Task-based influences, 65–67
 Technology, robotic, 2–4
 Temporal dynamics, 137–138
 Theory of mind, 8–9, 237
 Threat detection, 72
 Threat-stimulus releaser, 142
 Timing parameters, 188, 192
 Timing of responses, 35
 Tinbergen, Nikolaas, 45, 129, 131, 134
 Top-down contributions, 65–67
 Tour guides, robotic, 3–4
 Toy-present releaser, 140
 Trevarthen, Colwyn, 28, 30
 Triesman, Ann, 63, 78
 Tronick, Edward, 28–29, 31–32, 37, 127
 Turn-taking phases, 144–145
 Tyrrell, Toby, 132
- Under-stimulated regime, 109
 Understanding
 challenge of creating, 239–240
 interaction and, 8, 10–11
 University of Southern California (USC), 20
- Utterances. *See also* Expressive vocalization system
 extensions to, 209
 generating, 195–198, 209
 producing novel, 185
- Valence tag, 96
 Value-based system, 48
 Vanderbilt University, 24
 VAP (vocal affect parameters), 187–189, 194–195
 Variation, introducing, 34–35
 Vergence movements, 212
 Versatility, expressive, 158
 Vestibulo-ocular reflex (VOR), 213, 215, 226
 Vision of sociable robots
 applications of robots and, 1–4
 Kismet and, 5–6
 science fiction and, 1
 social intelligence components and, 6–11
 being there, 7
 being understood, 10–11
 human-aware, 8–10
 life-like quality, 7–8
 socially situated learning, 11
- Vision system
 design issues, 61–69
 attention activation map, 67–68
 bottom-up contributions, 63–65
 eye movement, 68
 habituation effects, 68–69
 overview, 61–63
 top-down contributions, 65–67
 evaluation criteria, 72–77
 gain adjustment on looking preference, 74
 gain adjustment on saliency, 72–74
 overview, 72
 socially manipulating attention, 74–77
 function of, 61, 79–80
 hardware design, 54–55
 limitations and extensions, 77–78
 low-level perception and, 59
 overview, 61
 post-attentive processing and, 69–72
 eye detection, 69–70
 loom detection, 71–72
 overview, 69
 proximity estimation, 71
 threat detection, 72
 Visual attention, 215–217
 Visual behavior, 211–213, 220–223
 Visual morphology, similar, 214–215
 Visual motor skills, 220
 Visual perception
 low-level, 216
 similar, 215

- Visual-motor system
 - design issues, 213–215
 - human, 211–213
 - limitations and extensions, 225–227
 - oculo-motor system and, 216–220
 - overview, 211
 - social amplification evidence and, 223–225
 - social interplay and, 221–223
 - visual behavior and, 220–221
 - visual motor skills and, 220
- Vocal affect parameters (VAP), 187–189, 194–195
- Vocal-play behavior, 138, 144, 153–154
- Vocalization system. *See also* Expressive vocalization system
 - design issues, 85–87
 - hardware design, 56–57
 - speaker-dependent, 86
 - speaker-independent, 86
- Voice. *See* Human speech; Vocalization system
- Voice-quality parameters, 188, 192–193
- VOR (vestibulo-ocular reflex), 213, 215, 226

- Waters, Keith, 204
- Weighted interpolation scheme, 169
- Windows NT (software), 55–56
- Withdraw behavior, 142–143
- Wolfe, Jeremy, 61

- Youthful appearance of sociable robots, 51