6.S196 / PPAT: Principles and Practice of Assistive Technology

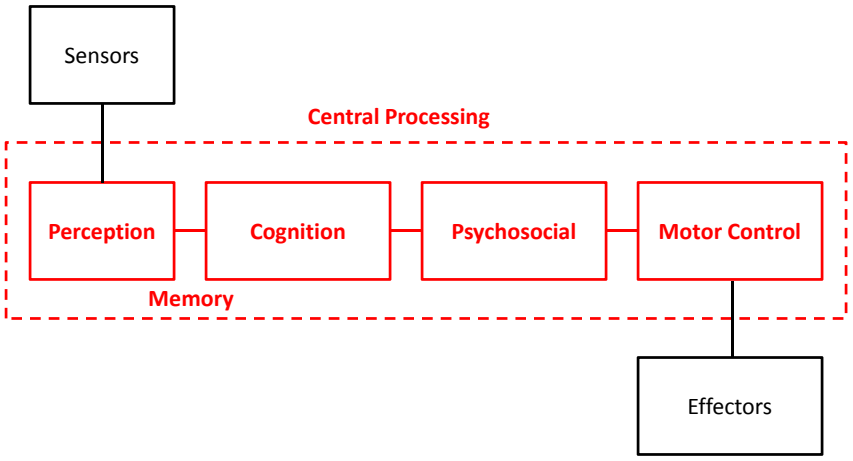
Today: Information Processing Model of the Human User (II) [C&H Ch. 3]

Wednesday, 3 October 2012
Prof. Seth Teller

Today

- Information processing model of human operator with a disability
- Consideration of how disabilities affect human performance model
- Implications of disabilities for design, selection and use of assistive technologies

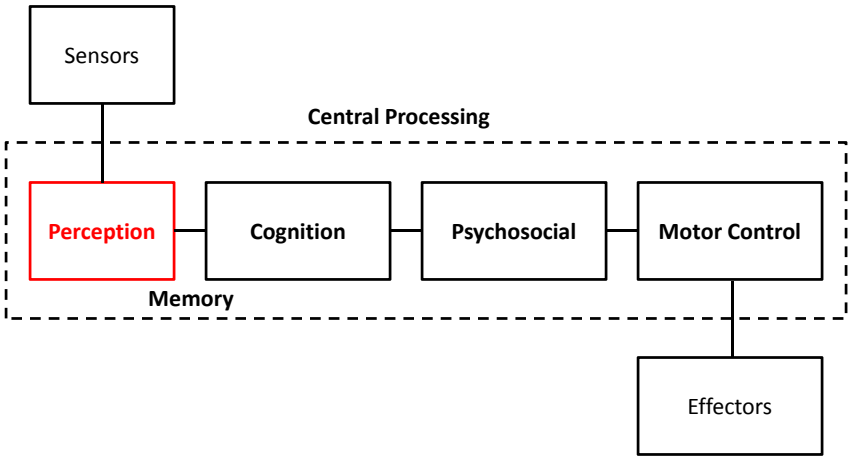
Information Processing Model



Central Processing Functions

- Interposed between sensors and effectors
- Include:
  - Perception
  - Cognition
  - Psychological factors
  - Neuromuscular control & motor planning

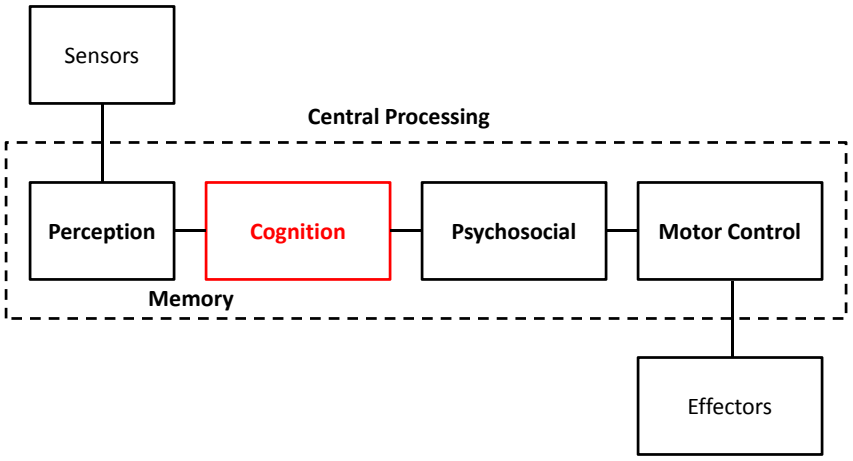
Information Processing Model



Perceptual Function and AT Use

- Addition of *meaning* to raw sensory data
- Thresholding
  - Output production above a minimal input level
- Figure-ground discrimination
  - Separating one portion of signal from another
- Localization
  - Placement of visual/auditory source in space
- Estimation of physical parameters
  - Length, distance, time (reaching, selection, control etc.)

Information Processing Model



Cognitive Function and AT Use

- Cognitive development
  - Maturation, experience, changes in ability
- Piaget's stages of development
  - Sensorimotor actions to symbolic thinking
- Memory
  - Sensory, short-term, long-term
  - Encodings, recall, recognition
- Language
- Problem-solving

Cognitive Development

- Development is a function of both:
  - Biological maturation (growth)
  - Interaction with environment (learning)
- AT designers and providers must consider both current status, development change
- Capabilities for manipulation or other purposive motor actions, symbolic thinking, logical problem-solving

Piaget's Stages of Development

- Sensorimotor (to age ~2)
  - Schemes for dealing with immediate world
- Preoperational (to age ~7)
  - Use of symbols and internal images/models
- Concrete operational (to age ~11)
  - Logical thinking about concrete objects, actions
- Formal operational (age ~11 to adult)
  - Systematic thinking, abstract problem-solving

Key Concepts for ATP

- Observational learning (as young as 9 mos.)
  - Imitation of observed (but unpracticed) acts
- Co-occurrences
  - Inferences about causality, contingent results
- Animism
  - Attribution of life, consciousness to objects
- Active vs. passive learning
  - E.g., driver vs. passenger of wheelchair
- Implications?

Cognitive Deficits

- Undesirable to model impairments due to trauma simply as developmental delay
  - Delay or impairment is due to factors other than development
  - Often, individual with impairment exhibits a mix of significant skills and severe deficits
  - So, must attend to cognitive demands, and include learning and operational aids
  - Not *simpler*, but *different*: alternative modes of information presentation, sequencing etc.

Memory

- Sensory memory
  - Storage of data after cessation of stimulus
  - Afterimages (~250 msec.), auditory echoes (~5 sec.)
- Short-term (or working) memory
  - Temporary storage (20-30 sec.) of task information
  - Maximizing STM use: grouping, patterns
- Long-term memory (information of lasting value)
  - Turning on/using AT device; goals, destinations
  - Somatosensory memory, e.g. feel of joystick
- Recall vs. recognition

Language

- Symbol system used by speaker, listener
  - Orthography, pictography, hand movements
- Spoken language
  - Phonology (sounds) to pragmatics (function)
  - Children who can't speak still develop language
- Communicative intents
  - Needs, commands, interaction, personal, inquisitive, imaginative, informative
  - AT should support as many of these as possible

Problem Solving, Decision Making

- Problem solving
  - Discovery of a solution in a new situation
- Decision making
  - Weighing and selection among alternatives
- Both PS and DM depend on memory
  - Of past actions and contingent outcomes
- As novice AT user becomes expert user, dominant strategy shifts from PS to DM
- Training can facilitate both sets of skills

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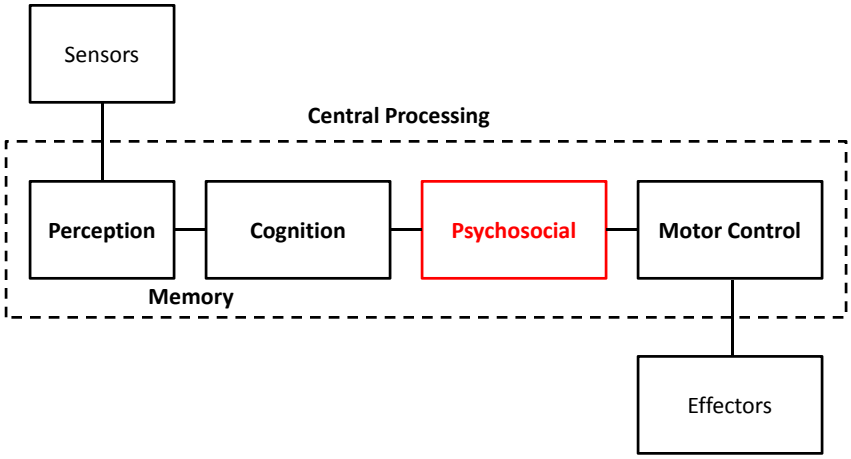

Psychosocial Function and AT Use

- Identity & self-protection
- Motivation
- Variation of characteristics over life span

Identity and Self-Protection

- Identity
  - Self-concept, locus of control, well-being
- Self-protection
  - Regulation of behavior, avoidance of harm
- Dependence on AT can cause anxiety
  - If device use causes emotional discomfort… may result in avoidance or abandonment
  - Those w/ congenital (vs. acquired) disability may be more likely to view AT as opening up opportunities (not as reminder of lost independence)

Motivation

- Influences that give rise to performance
  - From user, activity, context or the AT itself
  - Lack of motivation a major cause of abandonment
- Internal factors (primarily desire to succeed)
- External factors (praise, feedback)
  - Knowledge about performance
  - Motivation to continue until goal is achieved
  - Reinforcement (conversational interaction)
  - Coupling with social interaction
  - … Examples?

AT Use Over the Life Span

- Childhood to early teenage years
  - Eager to explore, interesting in experimenting
- Young to middle-aged adult
  - Engaged in job pursuits, want to succeed
- Middle-aged adults
  - May find technology awkward, threatening
  - Prefer to learn and practice in private
- Older adults
  - Little exposure to technology; may be fearful

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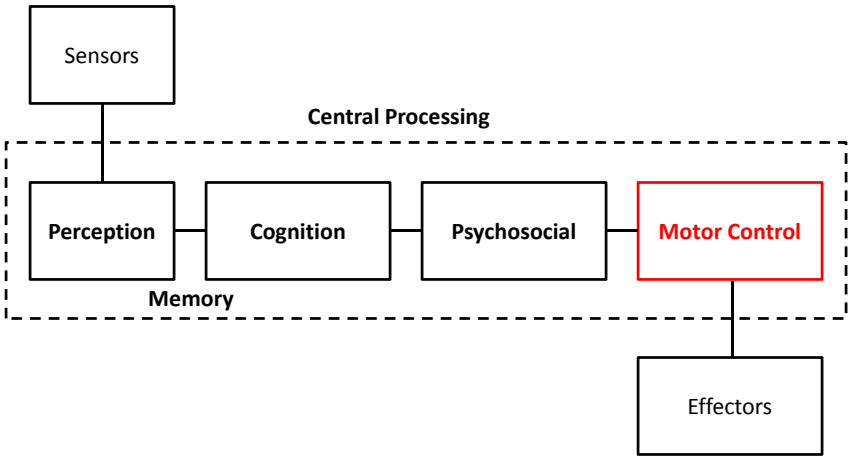

Motor Control and AT Use

- Central processing functions that lead to planned, coordinated motor outputs
  - Sensing for scanning, movement regulation
- Motor learning
  - Improved speed, accuracy with repetition
  - Lower cognitive burden, greater consistency
- Maps of internal neuromuscular system and external world, constructed as user encounters and experiences environment
- Example maps, potential disturbances?

Aimed Movement to Targets

- Requires several sensorimotor tasks
  - Scanning (device affordances, locations, objects)
  - Desired element must be chosen
  - Element must be activated or manipulated
- Speed generally subject to Fitt's Law (1954)
  - Time required to move to a target decreases for closer or larger targets, and increases for more distant or smaller targets
  - Holds for wide variety of body parts, controls
- Accuracy decreases with increasing speed
  - May not hold for expert users

Motor Learning and Patterns

- Huge number of potential motor trajectories for a given action
  - Few are exercised in actual situations
  - Path variability decreases with practice
- Implication: AT should exploit this tendency
  - Consistency of activation, rest affordances
  - Consistency of placement in dynamic displays
  - Predictability of choices

Relationship to Stimuli

- Motor performance is improved when correspondence between stimulus (e.g. AT system item or prompt) and user response is high
  - E.g., appearance of icons in file system GUI
- This is simply good interface design
- For AT systems, spatial mapping of stimulus to response is often best
  - Fastest response times, fewest errors

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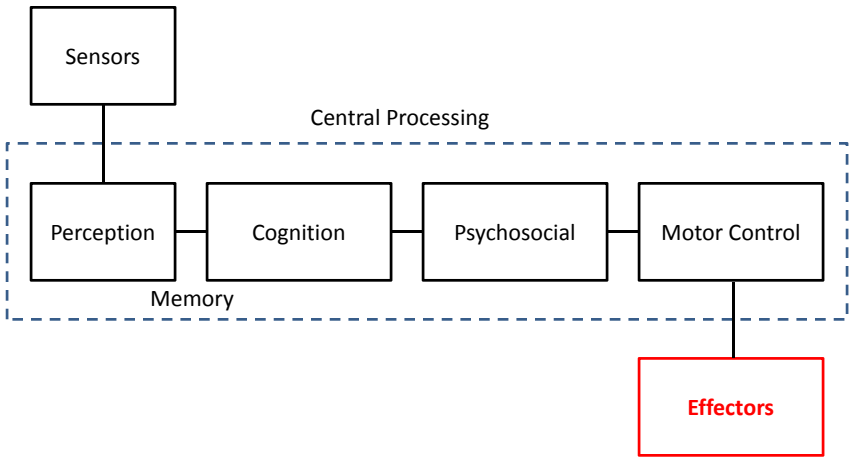

Effectors

- Neural, muscular, skeletal body elements that provide movement or motor output
  … under control of central processing
  … in response to sensory input
- Often AT controlled by hand movements
  … but many other control sites are possible
- Postural control and reflexes contribute to the generation of motor output

Effector Function and AT Use

- Motor outputs for stabilization, control
  - Large muscles of trunk and pelvis
- Control effectors for manipulation
  - Hand or fingers, shoulders, arm, head, eyes, eyelids, eyebrows, mouth, tongue, leg, foot
  - Respiration (flow of air, sip, puff)
  - Phonation (sound production, whistling, speech)
- Oculomotor control (via PCA, or AT device)
  - Approach, grasp, manipulation, release

Factors Underlying Effector Use

- Primitive reflexes (usually gone by ~6 mos.)
  - Tonic labyrinthine reflex (TLR): stiffening of back and leg muscles when head tilts back
  - Asymmetrical tonic neck reflex (ATNR): extension/bending of arm, leg when head turns to side
  - May be pronounced with neurological damage
- Righting and equilibrium reactions
  - Implications for upright posture, stable seating
- Muscle tone (flaccidity, spasticity, rigidity)
  - Fluctuation throughout the day

Characterizing Effector Movement

- Resolution
  - Degree of reliable fine control of objects
- Range
  - Maximal extent of movement possible
- Strength
  - Minimal force required to activate an interface
- Endurance
  - Ability to sustain a force, and repeat over time
  - Performance may decrease until total *fatigue*

Summary

- Emphasis on human operator
  - Information processing model
- Components underlying performance
  - Sensory, perceptual, cognitive, psychosocial, motor, effector movement characterization
  - Implications for AT design, selection and use

Coming Up

- Today (Wednesday) in lab:
  - Staff check-ins with each team
- Monday: no lecture or lab
  - Columbus Day holiday
- Next Wednesday's lecture:
  - Melissa Simonian, Braintree Rehabilitation Hospital will speak on Cognitive-Linguistic Disabilities
- Next Wednesday's lab:
  - Purchasing project-related components
  - Staff check-ins with each team