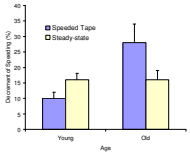
Week 16 Slides

Sensation, Cognition, or Both?

- Cognitive slowing or mounting sensory losses?
  - H1. Faster = disproportionately worse for older adults
  - H2. Faster = worse if older adults are at a sensory disadvantage
- Two methods of speeding
  - 'Speeding up the tape'
    - Affects speed, frequency, transitions
      - Demo
  - Reducing the duration of steady-state portions of the utterances
    - Affects speed, minimal distortion
      - Demo
- Signal processing takes cognitive effort
  - When transduction (sensation) is difficult, perception takes over

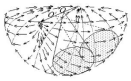


Sensation & Perception

- The trouble with Aging
  - Signal processing problems
    - Processing/Cognitive effort required to understand a signal
    - Use cognition for signal processing, less available for other tasks
  - When transduction (sensation) is difficult, perception takes over
  - Perception is part of cognition, limits cognitive abilities

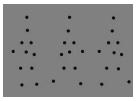
The BIG idea

- The study of perception or the study of perception and action?
  - Haptics (active touch), Speech (motor theory), dance
- The study of the modalities (vision, hearing) or the study of events?
  - Communicating, Approaching, Music
- The study of mistakes of perception or the study of its functionality?
  - 'Misdetection'?



What do we perceive?

- Expectation guided perception
  - Attention
- Intentions of others
  - Faces, speech, biological motion
- Combinations of information before awareness
  - Speech, echolocation, music, motion
    - Modal separation is *post hoc*
- Information necessary to communication and support actions



Revisiting old problems

- Where does meaning come from?
  - Associations
- How do we know which information to combine?
  - Psychophysical approach: process information separately
  - Constructivism: the brain (homunculus) puts it together
  - Systems/neural approach: adaptive association
- How does light get into muscle for the response?
  - Psychophysics: ???
  - Constructivism: ask the brain (homunculus)
  - Systems/neural approach: adaptive association

Ecological Psychology

- Direct perception
  - We perceive meaningful properties of the world
  - Redefine the world of the perceiving organism
    - "(Psychology) does not stand in awe of its subject matter…" (James J. Gibson)
    - What is the basis of perception?
      - Physical properties (psychophysics)
      - Sensory reactions (neuroscience)
      - Support of action (direct perception)

- The myth of reductionism – why isn't Psychology enough?
  - Perception of intent – vocal loudness is not reducible to intensity
  - Neural plasticity – varied neural response to a signal, constancy across responses
  - Emergent properties – the whole is not reducible to parts
    - Melody, termite nests
- Understand the system, not the parts
  - If perception starts with sensation there is a necessary disconnect from environment to perceiver

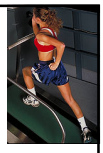
Ecological Approach to Perception

- Perception at the psychological level of analysis
  - Non-reducible to neural circuitry
    - No direct causation across levels (Ryle)
    - Sensation as by-product to perception
  - Non-reducible to physics
    - Redefine the physical description of the world

- Affordances for perception
  - Meaningful properties of the world
    - Ego-centric description
    - Niche-specific information

  - Requires information, not cues to perception
    - Tau is information – if detected, then time-to-contact is known
    - Co-articulation is information – if detected, speech is understood?

Constraints grant information



- Information & Constraints
  - Constraints must be met for information
    - Tau = constant object size/velocity
    - Texture = normal distribution
- Constraints limit information to specific contexts
  - Violation of constraint invalidates information
    - Perceiver adapts to non-reliance
    - Perceptual calibration
      - E.g., stepping off a treadmill, dragging behind a tractor, half-off a treadmill (Pick et al., 1999, 2000, 2005)

Perceptual Recalibration

- Adjusting to the use of affordances
  - (Demos)
  - Walking with a heavy book
    - Arm swing, stride length
  - Walking without a shoe
    - Speed, stride style

- Return
  - Pick's walking on a treadmill
    - Visual Flow + Muscular effort
- Muscular coordination by pendular mathematics

What information is available?

- Detection of time-to-arrival (catch-able, dodge-able)
  - Tau information
    - Ego-centric change

- Detection of walk-to-able/reachable
  - Texture information
    - Gradients = environment
- Detection of climb-up-able (riser height on stairs)
  - Eye-height information
    - Perceiver relative to environment

- Detection of communicate-able
  - Articulatory gestures
    - Modality-neutral actions

Direct Detection of Information

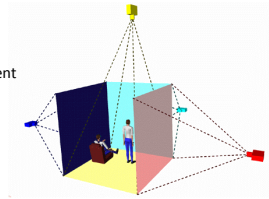
- Information detected as needed
  - Expectation for prospective behavior
  - Guides detection to affordance
- If affordance detected, perception is complete
  - Meaningful property supports action
    - E.g., eye-height proportioned to leg = riser height = step up
  - No representations, no perceptual processing, no homunculus

Implications of the Ecological Approach

- Study of animal in the environment
  - Perception evolved for detection of affordances
    - Affordances properties of environment
    - No environment = no affordances
- Study of functional properties
  - Organization of perception around behavior
  - Focus of real behaviors – requirements for safe action
- Study of invariant information
  - Lawfully available properties
  - Context dependent specificities

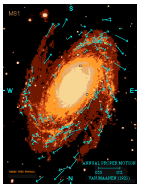
Techniques of Ecological Approach

- Analyze real actions
- Control environment
  - Virtual reality studies
    - The CAVE – immersion environment
- Control interaction
  - Change information
    - Eye-height, physical variables
- Constraints for action
  - Body movements/actions
    - Bio-motion



Combining Modalities

- Studying modalities from an Ecological Approach
  - Define modality (sensory vs. perceptual)
- Demo – Ambiguous Motion
  - Where does information come together?
- The Problems with Multiple Modalities
  - Separate processing of modalities
  - Requires combination
    - What and how much integration should occur
- Three solutions
  - Central processing
  - Synchronized processing
  - No processing (EcoPsy)

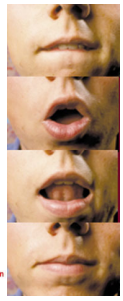


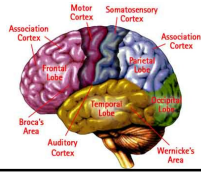
Central Processing

- Initial separate processing of stimuli
  - Separate receptors → separate cortical regions
    - Process then combine
- Central area of association
  - Complex algorithm for combination
    - Multiple co-occurrence
      - Potentiation of signals that co-occur
    - Bayesian algorithm
      - P (A|B), post processing
  - Powerful combination rules

Central Processing

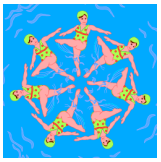
- Redundant signals
  - Strengthens association of modalities
  - Central processor can select most effective input
- Conflicting signals
  - Hierarchy of signal usage
    - Past experience with redundancy suggests most effective
- Neural description
  - Association cortex
- Synnergy?

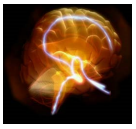




Synchronized Processing

- Reverberant patterns of interaction
- Binding problem without centralization
  - Neural oscillation to stimulation
    - Modular areas of brain synchronize oscillation
      - Common stimulating event
      - Common attributes of stimulus
  - Synchronization = combination
    - Interaction of modalities?
    - Post processing/parallel processing combination
  - Potential for synergy
    - Redundant patterns strengthen each other
- McGurk effect?- perception can differ from either modality





Modality-Neutral Hypothesis

- How do we separate the modalities?
- What makes smell different from taste, different from touch, different from hearing, different from vision?
  - (Give it a try – there must be differences?)
  - How many sensory modalities are there? Why are they different from each other?
    - Aristotle – separation of the modalities

Energy Divisions

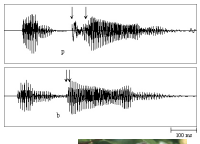
- E.g., Vibrational stimulation
  - Physical displacement caused by oscillation
    - Tactile, acoustic, visual, olfactory?
      - Speed, receptor, media dependent
- Can the modalities be separated by media?
  - Define media

Sensory Transducers

- E.g., Ears for hearing
  - Displacement of hair cell
    - Ear: frequency, pressure, temperature, chemical gradient, etc
- Can the modalities be separated by the sensory transducers?

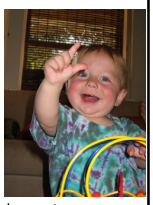
Neural Pathway

- E.g., Visual Pathway
  - Shimojo et al., ERP + fMRI
    - Early cross processing
- E.g., Speech/Auditory pathway
  - Calvert, MacSweeney et al., fMRI
  - Green, 1998: Sub-segmental processing
    - VOT (Voice onset time) is audiovisual
- E.g., Localization in Midbrain
  - Superior Colliculus (Owls, chimpanzee): Stein, Meredith et al.
- Can the sensory modalities be separated by neural pathway?



Evolutionary Basis of Separate Modalities

- Why did we evolve separate structures?
  - Functional separation of structures
  - Increasing specificity of detection
    - What are sensors meant to detect?
- Human perceptual development
  - Amodal perception
    - Lack of sensory distinction in early development
      - Habituation across modalities (Morrongiello, Walker-Andrews, et al.)
  - Learned separation based on principle media
    - Accurate separation???
      - Echolocation
      - Visual speech
      - Visuo-haptic manipulation (Shore, Spence, et al.)



Conclusions

- What does it all mean?
  - Modality-neutral
    - Perceptual modalities are not separate
    - Perception is organized around utility/function not modality-separation
- The Goal of perception