Psych 2220A Lecture 7

Hearing
- The auditory system (7.2)
- Auditory perception and stream segregation (not in text in detail)

Auditory Cortex
- Auditory cortex is located in the temporal lobe
- **Core** region: includes primary cortex
- **Belt** surrounds the core region
  – A band of secondary cortex
- Secondary cortex outside the belt
  – Referred to as **parabelt** areas
- About ten separate areas of secondary auditory cortex in primates

Organization of Primate Auditory Cortex
- Functional columns (cells of a column respond to the same frequency)
- Tonotopic organization
- Secondary areas do not respond well to pure tones, likely important for more complex features of sounds

Stimuli
- Still much to learn about dimensions of sounds processed in different parts of auditory cortex
- Challenge of using simple sound stimuli (tones)

– easy to manipulate, but lack complex features that the cortex may be designed to process
– many cortical cells respond to vocalization sounds

Two Streams of Auditory Cortex
- Auditory signals are conducted to two areas of association cortex

– Prefrontal cortex
– Posterior parietal cortex

- Anterior auditory pathway may be more involved in identifying sounds (what)
- Posterior auditory pathway may be more involved in locating sounds (where)

Auditory-Visual Interactions
- There is evidence for interactions between the auditory and visual systems

– e.g. some posterior parietal neurons with both visual and auditory receptive fields

- Interaction in primary sensory cortices indicate that sensory system interaction is an early and integral part of sensory processing

McGurk effect
- Phonemes often vary continuously, but are perceived categorically
- Visual and auditory input of two phonemes can give rise to perception of intermediate phoneme!
- http://www.youtube.com/watch?v=G-lN8vWm3m0

Psych 2220A Lecture 7

Where Does the Perception of Pitch Occur?
- Most auditory neurons respond to changes in frequency rather than pitch
- One small area just anterior to primary auditory cortex has neurons that respond to pitch rather than frequency

– May be where frequencies of sound are converted to perception of pitch

Effects of Damage to the Auditory System
- **Lesions of auditory cortex** in rats results in few permanent hearing deficits
- Lesions in monkeys and humans hinder sound localization and pitch discrimination
- Deafness in humans

– Total deafness is rare, due to multiple pathways
– Two kinds: **conductive deafness** (damage to ossicles) and **nerve deafness** (damage to cochlea)
– Partial cochlear damage results in loss of hearing at particular frequencies

Auditory Scene Analysis
- Cocktail party phenomenon

– Pop-out of salient stimuli
- Stream segregation

– Complex auditory stream partitioned into individual auditory objects
- Completion of partial stimuli

– Specialized perception of phonemes and speech

Stream segregation
- Auditory streams segregate based on pitch similarities and timing

Completion of Partial Stimuli
- Picket fence effect

* Somatosensory System Text Section 7.3 *

Somatosensory Homunculus
- Homunculus = “little man”
- Shows the relative size of the somatosensory representation devoted to various body parts
- Do you notice a relationship between the size of the representation and the sensitivity (e.g., two-point touch threshold)?

Somatosensory System: Touch and Pain
- Somatosensory system is three separate and interacting systems:
- **Exteroceptive** – external stimuli
- **Proprioceptive** – body position
- **Interoceptive** – body conditions (e.g., temperature and blood pressure)

Psych 2220A Lecture 7

Cutaneous Receptors
• Free nerve endings
– Temperature and pain
• **Pacinian corpuscles**
– Adapt rapidly, large and deep; onion-like
– Respond to sudden displacements of the skin
• **Merkel's disks** – gradual skin indentation
• **Ruffini endings** – gradual skin stretch

Dermatome
• The area of the body innervated by the left and right dorsal roots of a given segment of spinal cord
• Considerable overlap between adjacent dermatomes

Two Major Somatosensory Pathways
• Dorsal-column medial-lemniscus system
– Mainly touch and proprioception
– First synapse in the dorsal column nuclei of the medulla
• Anterolateral system
– Mainly pain and temperature
– Synapse upon entering the spinal cord
– Three tracts – spinothalamic, spinoreticular, spinotectal
• Lots of overlap in function of these two pathways

Spinal Injury
• Transection of both paths leads to complete lack of sensation below the level of the cut

Cortical Areas of Somatosensation
• Primary somatosensory cortex (SI)
– Postcentral gyrus
– Somatotopic organization (somatosensory homunculus) – more sensitive, more cortex – Input largely contralateral
• SII – mainly input from SI
– Somatotopic; input from both sides of the
• Much of the output from SI and SII goes to association cortex in posterior parietal lobe

Platypunculus?
• Platypus homunculus (platypunculus?)
– Platypus has tactile and electrosensory receptors – bill = 75% of S1

Receptive Fields of S1 Neurons
• Similar to V1, many neuron's receptive fields have antagonistic excitatory and inhibitory areas
• Columnar organization: in a column receptive fields are for same part of the body

Psych 2220A Lecture 7

Effects of Damage to the Primary Somatosensory Cortex
• Effects of damage to the primary somatosensory cortex are often mild
– Likely due to numerous parallel pathways

Somatosensory System and Association Cortex
• Highest level of sensory hierarchy are areas of association cortex in prefrontal and posterior parietal cortex
• Posterior parietal cortex contains bimodal neurons
– Neurons that respond to activation of two different sensory systems
– Allow integration of visual and somatosensory input

Somatosensory Agnosias
• **Astereognosia** – inability to recognize objects by touch
– Pure cases are rare – other sensory deficits are usually present
• **Asomatognosia** – the failure to recognize parts of one's own body

Perception of Pain
• Despite its unpleasantness, **pain is adaptive** and needed
• **No obvious cortical representation** of pain (although the anterior cingulate gyrus appears involved in the emotional component of pain)
• **Descending pain control** – pain can be suppressed by cognitive and emotional factors

Descending Pain Control
• Circuitry identified by the following studies:
• Electrical stimulation of the periaqueductal gray (PAG) has analgesic effects
• PAG and other brain areas have opiate receptors
• Existence of endogenous opiates (natural analgesics) – endorphins

Neuropathic Pain
• Severe chronic pain in the absence of a recognizable pain stimulus
• Likely from pathology of nervous system linked to an injury
• Some evidence for aberrant glial cell signals triggering neural pain pathways

Chemical Senses: Smell and Taste
• Olfaction (smell)
– Detects airborne chemicals
• Gustation (taste)
– Responds to chemicals in the mouth
• Food acts on both systems to produce flavor

Chemical Senses: Smell and Taste
• Pheromones are chemicals that influence that behavior of conspecifics (members of the same species)
• Evidence of human pheromones

Psych 2220A Lecture 7

- Changes in olfactory sensitivity across and
- Synchronization of menstrual cycles
- Sex identification by smell (especially by women)
- Men can identify menstrual stage by smell

Olfactory System
- Receptor cells embedded in the olfactory mucosa of the nose
- Many different kinds of receptors – Rats and mice have about 1,500
– Humans have almost 1,000
- Same kinds of receptor cells project to similar areas of the olfactory bulb
– Clusters of neurons near the surface of the olfactory bulbs
  - Olfactory glomeruli
- New receptor cells are created throughout life
- Olfactory tract projects to several structures of the medial temporal lobes including amygdala and piriform cortex
– Does NOT first pass through the thalamus
– Only sensory system that does this

Gustatory System
- Receptors in tongue and oral cavity in clusters of about 50 called **taste buds**
– Located around small protuberances called papillae
- > 4 (sweet, sour, salty, bitter) primary tastes – 5th is *umami,* meat or savory
- Many tastes not created by combining primaries
- Salty and sour don't have receptors; they merely act on ion channels
- Gustatory afferent neurons leave the mouth as part of the 7th, 9th, and 10th cranial nerves to the solitary nucleus of the medulla
- Projections then pass to the ventral posterior nucleus of the thalamus
- From there, neurons project to the primary gustatory cortex and then to the secondary gustatory cortex

Brain Damage and the Chemical Senses
- **Anosmia** – inability to smell
– Most common cause is a blow to the head that damages olfactory nerves or temporary damage to mucosa
– Incomplete deficits seen with a variety of disorders
- **Ageusia** – inability to taste
– Rare due to multiple pathways carrying taste information

Selective Attention text section 7.5
- Improves perception of what is attended to and interferes with that which is not
- Internal cognitive processes (**endogenous attention**) and external events (**exogenous attention**) focus attention

Psych 2220A Lecture 7

Change Blindness

• **Change blindness** – no memory of that which is not attended to
– We do not appear to remember parts of a scene that are not the focus of our attention

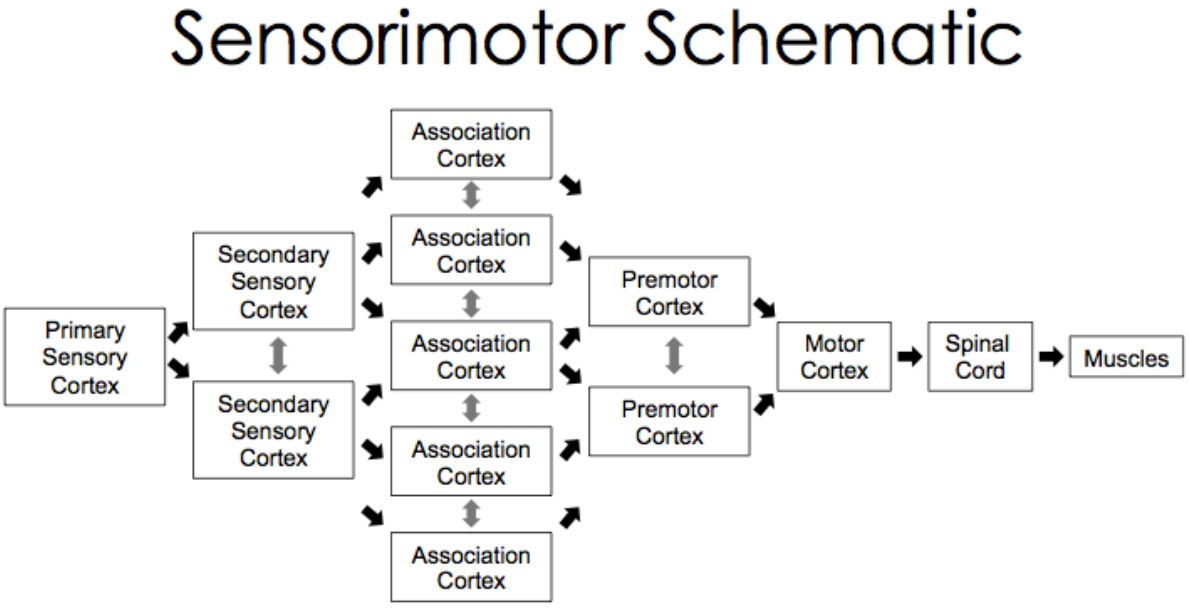
Neural Mechanisms of Attention

• Selective attention is thought to work by strengthening the neural responses to attended-to aspects and by weakening the responses to other
• For example, spatial attention can shift the location of receptive fields

Sensation and Perception

• What is the function of perception?
• To provide useful (if not truthful) representations of the world around us
• To guide action

* Sensorimotor System Chapter 8 *



Sensorimotor Association Cortex

• Posterior parietal association cortex
• Dorsolateral prefrontal association cortex
• Each composed of several different areas with different functions
• Some disagreement exists about how to divide the areas up

Posterior Parietal Association Cortex

• Integrates information about
– Body part location
– External objects
• Receives visual, auditory, and somatosensory information

Psych 2220A Lecture 7

• Outputs to motor cortex
– Including dorsolateral prefrontal association cortex, secondary motor cortex, and frontal eye field

Damage to the Posterior Parietal Cortex
• **Apraxia** – disorder of voluntary movement – problem only evident when instructed to perform an action – usually a consequence of damage to the area on the left
• **Contralateral neglect** – unable to respond to stimuli contralateral to the side of the lesion – usually seen with large lesions on the right

Dorsolateral Prefrontal Association Cortex
• Input from posterior parietal cortex
• Output to secondary motor cortex, primary motor cortex, and frontal eye field
• Evaluates external stimuli and initiates voluntary reactions

Dorsolateral Prefrontal Association Cortex
• Primates exhibit variety of neural responses
• Some respond to external stimuli
– characteristics of objects
– location of objects
– combination of characteristics (e.g. shape) and location
• other neurons fire prior to onset and throughout a response

Secondary Motor Cortex
• Input mainly from association cortex
• Output mainly to primary motor cortex

Identifying the Areas of Secondary Motor Cortex
• At least eight different areas:
• Three supplementary motor areas
• Two premotor areas
– Dorsal and ventral
• Three cingulate motor areas

Identifying the Areas of Secondary Motor Cortex
• Secondary motor cortex may be involved in programming movements in response to input from dorsolateral prefrontal cortex
– Active during imagining or planning of movements

Mirror Neurons
• Active when performing an action or watching another perform the same action
• In monkey studies, mirror neurons fired while
– Grasping or watching another grasp a particular object but not other objects
– Grasping or watching another grasp an object for a specific purpose but not for another purpose

Psych 2220A Lecture 7

• Possible neural basis of social cognition (knowledge of others' mental processes – e.g., intentions)
• Likely to be found in humans
– Indirect evidence from functional brain-imaging studies

Primary Motor Cortex
• Initial studies by Penfield used brief low- intensity stimulation
• Elicited simple motor reflexes
– Somatotopic organization
– Motor homunculus
• However, longer more realistic stimulation elicit more complex and naturalistic movements

Primary Motor Cortex
• Firing of neurons is often correlated with end goal of movements, even if different trajectory taken
• Recording from primary motor cortex can be used to drive prosthetics and robots

Primary Motor Cortex Lesions
• Small lesions often with minimal effects
• Large lesions may disrupt a patient's ability to move one body part independently of others
• Large lesions may also produce **stereognosia**
– Deficit in stereognosia (ability to identify an object by touch)

Cerebellum and Basal Ganglia
• Interact with different levels of the sensorimotor hierarchy
• Coordinate and modulate
• May permit maintenance of visually guided responses despite cortical damage

Cerebellum
• 10% of brain mass, but more than 50% of its neurons
• Input from primary and secondary motor cortexes
• Input from brain stem motor nuclei
• Feedback from motor responses
• Involved in timing, fine-tuning, and motor learning
• May also do the same for cognitive responses

Basal Ganglia
• A heterogenous collection of interconnected nuclei
• Part of neural loops that receive cortical input and send output back via the thalamus
• Modulate motor output and cognitive functions including learning