Final exam study guide (chapters 12, 13, 14 and 15)

About 50% of the final will be from old material, so please look over the study guides for Exams 1, 2 and 3 as well.

Chapter 12: Sound Localization and the Auditory Scene

1) Auditory Localization – the where pathway: determining azimuth and elevation of sounds
- a) Cues for determining azimuth (horizontal position, with 0 degrees straight ahead)
  - ITD, Interaural time difference – time for sound to get from one ear to the other
    - About 0.6 msec for a sound directly off to the side.
    - Best for low frequencies, worst for high frequencies
    - 'Cone of confusion' sets of cones emanating from the ear where ITD Is the same
  - ILD, Interaural level difference – difference in sound intensity caused by 'shadow' of head
    - Best for high frequencies, worst for low
  - HRTF Head related transfer function (spectral cue)
    - Shape of pinna influences spectrum of sound differently from different locations.
    - Must be learned - inserting plugs in ear screws up ability to localize sounds, but improves over time. Localization comes back immediately after removing plugs.
- b) Physiology of auditory localization
  - ITD detectors found in superior olivary and auditory cortex.
  - Topographic maps (maps for location of auditory stimulus) found in the Barn owl.
  - Multimodal neurons showing maps for spatial position in the association cortex of the cat respond to location of visual, auditory or visual and auditory stimuli.
  - Panoramic neurons – evidence that location is coded in the *pattern* of firing of a neuron, rather than by *which* neuron is firing (such as in a topographic map).

2) The Auditory Scene – the what pathway: identifying, separating and grouping auditory sources
- a) rules of auditory grouping (similar to Gestalt rules for vision)
  - Similarity (of timbre and pitch)
    - Wessel effect example (similarity of timbre)
    - Bergman and Campbell, and Bach examples (similarity of pitch)
  - Similarity of location – sounds from same location group together
    - Deutch scale illusion/: pit similarity of localization (ear) against pitch – pitch wins
  - Good continuation - sound continues 'behind' noise mask
  - High-level cues – recognizing a familiar tune overlaid on another helps to segregate
- b) Hearing inside rooms – effects of reflected sounds
  - When a second sound lags behind a lead sound, percept depends on delay:
    - i) no delay: sound comes from the middle
    - ii) <1 msec: sound comes from position near the lead sound
    - iii) 1-5 msec: sound comes only from the lead sound location (precedence effect)
    - iv) >5 msec: lag sounds like an echo (5 msec is the echo threshold)
  - Architectural acoustics:
    - Reverberation time (1.5- 2 sec is good)
    - intimacy time (best is around 20 msec)
    - bass ratio (high is best)
    - spaciousness factor (high is best)

3) interactions between sight and sound:
- Sekuler's bouncing balls demo: auditory click affects visual percept
- McGurk effect (see later chapter on speech)
- Visual Capture – voices seem to come from the screen, not the speaker.

Chapter 13: Speech Perception

47 phonemes: 13 vowel sounds + 24 consonant sounds for English
The sound spectrogram: image of frequencies over time.
Vowel sounds produced by vocal cords and shape of vocal tract.
Vowel sounds have resonant frequencies, or formants: lowest is *first* formant
Consonants are produced by constriction of vocal tract.
` The Segmentation problem: separating continuous speech sounds in to separate parts
The Variability problem: different speakers have different accents and pronunciations.
Invariant acoustic cues:
Voice Onset Time (VOT). Delay between consonant and vowel determines perception of 'ba' vs. 'pa' and 'da' vs 'ta'. Within a category each sounds the same.
Cognitive dimensions of speech – lots of top-down influence over perception of speech
- -we're better at responding to words than nonwords
- -we can fill in for a cough sound inserted in to speech (phonemic restoration)
- -we're better at 'shadowing' normal sentences than anomalous sentences or sounds

Speech perception in the brain
- Broca's area: more anterior: involved with speech production
  - Damage leads to Broca's aphasia (stilted speech)
- Wernicke's area: more posterior: involved with speech comprehension
  - Damage leads to Wernike's aphasia (garbled speech, or word salad)

Experience and Speech perception
- Before age 1, humans can discriminate sounds in all languages,
- But by adulthood, we loose the ability to discriminate some sounds in foreign languages (e.g. 'l' vs 'r' for Japanese speakers)

We are 'tuned' for language-like sounds
- Demonstration of imitating backward speech, and playing it backward

Synesthesia – individuals experience a second sensation associated with a stimulus. Types include:
- Music – color
- Grapheme-color -> fMRI responses in V4 for synesthetes reading letters and numbers
  - Measured by Stroop effect, pop-out experiment, and by crowding experiment.
- Number-form
- Lexical-gustatory
- Taste-shape
- Face-color (the neuronal basis of auras?)

Chapter 14: The Cutaneous Senses

Sense organs for touch: 4 types of mechanoreceptors
- Merkel receptors, or SA1
  - Low temporal frequency, small receptive fields, slow adapting
  - best for determining shape by pressing on objects
- Pacinian corpuscle, or RA2
  - High temporal frequency, large receptive fields, rapid adapting
  - Best for determining texture by moving fingers across objects
- Meissner receptor, or RA1
  - Low temporal frequency, smaller receptive fields, rapid adapting
  - Best for feedback for gripping tools (but not really known)
- Ruffini receptor, or SA2
  - High temporal frequency, large receptive fields, slow adapting
  - Probably feedback for stretching

Perception of texture depends on two cues:
1) distribution of depressions on skin that stimulates a pattern across receptors (spatial profile)
2) rate of vibration within a given receptor as it passes over a surface. (temporal frequency)
   - This second sort of cue requires active perception – moving fingers across the surface.

2 Pathways from skin to somatosensory cortex (SA1)
- Medial leminscal pathway for touch
- Spinothalamic pathway for pain
- Both cross over to the opposite hemifield of brain

Penfield's somatosensory homunculus: representation on body for sense of touch in somatosensory cortex.

Phantom limb disorder: pain and other sensations in missing limb

Ramachandran's experiments showing:

-Face representation of Penfields' map are probably upside down

Plasticity of somatosensory cortex:

- stimulation of finger of monkeys increases size of finger representation in SA1
- focal dystonia (musician's cramp) caused by fusing of finger representations

Perceiving spatial detail by touch:

Tactile acuity thresholds (two point separation, grating orientation)

Thresholds for tactile acuity increase from finger tip to palm

reflected by density of Merkel receptors

Thresholds for tactile acuity increase from index to pinky

Not reflected by density of Merkel receptors, but

Are reflected by representation in S1 (larger for index finger)

Correlation amongst individuals – lower acuity thresholds -> larger S1 representation.

Areas with higher tactile acuity have smaller receptive fields for Merkel receptors

Perceiving spatial detail through vibration (movement of fingers across surface)

Pacinian corpuscle: rapid adaptation due to mechanics of the corpuscle, not neural via a neural adaptation mechanism.

We're better at judging roughness of texture if we can sweep fingers across surface

Hollins' experiment showing through selective adaptation that Pacinian corpuscle is used for texture perception:

Adapting the Pacinian corpuscles by adapting to 250Hz stimulation decreased performance, but adapting to 10Hz stimulation (Meissner receptors) did not.

Physiology of tactile perception

Thalamus shows center-surround organization (like the LGN)

S1 has neurons with orientation selectivity

Higher somatosensory areas are selective to shape

Braille reading

Experts can read 100 wpm, good, but less than 250-300 for visual reading

Finger representation for 3-finger Braille readers are distorted (like focal dystonia)

Braille reading excites visual cortex in fMRI experiments

The star nosed mole is the king of somatosensory perception!

Pain perception (nociception)

Recent research has emphasized the role of top-down (cognitive) aspects of pain perception.

Three ways to experience pain:

1) Nociceptive: directly through stimulation of nociceptors (pain receptors)
2) Inflammation: indirectly through nociceptors via inflammation or tissue damage
3) Neuropathic: indirectly through stimulation of pain pathways (e.g. damage to nerves in pain pathway)

Neural pathways for pain – the pain matrix

Nocireceptor responses go through the spinothalamic pathway to

1) subcortical areas: hypothalamus, limbic system and thalamus
2) corical areas: S1, S2, insula and anterior cingulate

Hoffauer's experiment showing that sensation and perception of pain can be dissociated using hypnosis.

Subjects that are more easily hypnotized can control awareness of pain, and have larger anterior corpus callosum.

Chapter 15: The Chemical Senses

Smell

Rats and Dogs are macrosmatic and are more sensitive to odors than humans (microsmatic), but our receptors are equally sensitive – the difference is convergence.

Humans are sensitive to odors without conscious awareness:

Stern and McClintock's experiment showing synchrony of menstrual cycles via underarm secretions.

Males' ratings of sexual attractiveness vary with day of menstrual cycle.

Psychophysics of smell:

- Odors are delivered through an olfactometer.
- Usual tools are used: detection, forced choice, discrimination
- Weber's law holds for odor intensity: Weber fraction around 11%

Unlike colors, we can detect but not easily identify odors
Unlike colors, there is no obvious psychological 'space' for odors (despite Henning's efforts)
Smell is complicated: similar chemicals can smell different, different chemicals can smell similar.
Structure of the olfactory system

- Odorants are picked up by receptors in the mucosa in the top of nasal cavity.
  - Mucosa contains four 'zones'. A given receptor is found in only one zone.
- There are about 350 types of olfactory receptors
- Signals are then carried to the glomeruli in the olfactory bulb.
  - Olfactory bulb has a representation of the same zones.
- Signals then sent on to:
  - Primary olfactory (piriform) cortex
  - Secondary olfactory (orbitofrontal) cortex (also associated with taste)
  - Amygdala (associated with emotion or valence)

With 350 receptors, are odors represented through specificity or distributed coding?

- Probably distributed coding – leaving to billions of possible combinations of responses

Taste perception

There seem to be 5 basic qualities for taste.

- Sweet, sour, bitter, salty and don't forget umami.
- Tongue doesn't have selective areas for different tastes
- and the orbital frontal cortex (like smell)

Flavor = Taste + Smell

- Perception of some compounds are affected by smell, just a few (like MSG) are not

pSupertasters: 35% of women, 15% of men

- Appear to have – different response to PTC and PROP. More sensitive to bitter tastes.
- Supertasters have more taste buds, and more specialized receptors.