Exam 3 study guide

As always, please feel free to email me questions any time.
(gboynton@u.washington.edu).

Many of the experiments below are associated with a researcher (e.g. Britten et al.). You don't need to memorize these names; you just need to understand the experiments and the results.

Chapter 7: Color Vision, starting with Opponent Process Theory
(Key terms are on page 16)

- Opponent Process theory (Hering)
  - Color opposites and afterimages
  - Red vs. Green perceived through differences in the response to L and M cones. (More L responses lead to more red appearance)
  - Blue vs. Yellow perceived by difference between L+M and S cone responses (More S responses lead to more blue appearance)
- Other factors influencing color perception
  - Color and lightness constancy
  - Other color illusions.

Chapter 8: Perceiving Depth and Size

Cues to depth perception

Oculomotor cues

1. Convergence (vergence movements to point both eyes at one location)
2. Accommodation (feedback from muscles focusing the lens)

- Monocular
  1. Pictorial cues
     - a. Occlusion
     - b. Relative height
     - c. Relative size
     - d. Perspective convergence (sometimes called linear perspective)
     - e. Familiar size
     - f. Atmospheric perspective
     - g. Texture gradient
     - h. Shadows
  2. Movement produced cues
     - a. Movement (motion) parallax
     - b. Deletion and accretion (motion-induced occlusion)
- Binocular (Disparity) – use of different images in the two retinas
  - The horoptor: circle of points that passes through the point of focus; objects on the horoptor produce no disparity.
  - Crossed disparity – objects in front of the horoptor
  - Uncrossed disparity – objects behind the horoptor.
  - Disparity allows you to see depth in disparate images, random dot stereograms and autostereograms.

Physiology of Depth Perception

- Hubel and Wiesel found disparity tuned cells (binocular depth cells) in cat area 17.
- Blake and Hirsch showed that experience was needed to form binocular depth cells.
- Many adults (around 10%) cannot use binocular disparity for depth.

Know which cues are good for which distances (e.g. Stereopsis good only up to about 6 feet, atmospheric perspective for long distances etc.)

Size perception

- Visual angle – degrees of angle that an object subtends in the world (and on the retina)

Size Constancy – perception of size doesn't change despite varying sizes on the retina
Size-distance equation: Perceived Size is proportional to Retinal Size X Perceived Distance
Size-distance scaling: changing perceived distance changes perceived size. (e.g. Emmert's law)
Visual illusions associated with size constancy by manipulating perceived depth:
Shepard's monsters in the hallway illusion
Ponzo illusion
Muler-Lyer illusion
Shepard's 'tables illusion'
Measuring size constancy in psychophysics and the brain
Murray et al's experiment showing how perceived size changes fMRI responses in V1.

Moon illusion: moon appears larger on horizon – must mean it looks farther away. But it actually looks closer. We don't really know why.

Chapter 9: Perceiving Movement

Four ways to perceive movement:

1. Retinal motion (movement of images on the retina). Necessary for kinetic depth effect.
2. Apparent movement (or motion). Objects that jump from one place to another appear to move. Revisited at end of chapter:
   Motion of objects tends to take the shortest path and not change shape.
   But can chance shape with 'transformational apparent motion'.
3. Induced movement
4. The motion aftereffect

Physiological basis of motion perception:
Direction-selective neurons found in V1, and especially MT.
MT is part of the dorsal pathway (receives primarily magnocellular input)
Motion-responsive areas found in humans with fMRI is called area MT+

The aperture problem:
Direction of bar sliding across an aperture (or receptive field) is ambiguous. (sometimes called the 'barber-pole illusion')
Shape of aperture affects perceived direction, probably due to the overall direction of terminators (junctions between bars and the edge of the aperture).

Gratings and plaids: Plaids are made by adding moving gratings together.
Direction of plaid determined by an intersection of constraints by component gratings
MT Component cells respond best when components of plaids are in preferred direction.
MT Pattern cells respond best when whole plaid pattern moves in preferred direction.

Biological motion (point light walkers)
Specific example of kinetic depth effect. Conveys lots of information in an impoverished stimulus, such as action, gender, mood, and weight.
Superior temporal sulcus (STS) responds to biological motion – is connected to both the dorsal and ventral pathways.

Corollary discharge: How the visual system deals with retinal motion during eye movement
Copy of image movement signal sent to 'comparator' to subtracted expected retinal motion signal (as opposed to simply suppressing the visual system during eye movement).
Ways to experience effects of corollary discharge:
Afterimages in the dark, pushing on eyeball, command to move paralyzed eyes.

Physiological evidence for corollary discharge: brain damage leads to motion perception during eye-movement (may be associated with dyslexia). Monkey MST has neurons that do not respond during eye movement, despite retinal motion.

Linking MT with motion perception

Newsome and colleagues' experiments show (using correlated dot stimuli)

1. lesion of MT impairs motion perception
2. monkey's 'guesses' at 0% correlation are reflected in MT responses
3. microstimulationg a direction-selective column in MT biases monkey's decision about direction of motion.

Iimplied motion: Kourtzi and Kanwisher found that viewing images of people in motion produced fMRI responses in MT+.

Motion induced blindness illusion – motion can make things disappear (why? We don't know).

Chapter 10: Perception and Action

Active vision – moving your eyes or your body to affect the visual signal in useful ways (as seen previously with eye-movements and motion parallax)

Gibson's ecological approach to vision – vision requires action in a natural environment.

Optic flow – flow patterns on the retina induced by moving observer in stationary environment.
Optic flow cues the direction of motion through:

1) Gradient of flow (direction and speed of motion on retina).
2) Focus of expansion (region of visual field where there is no flow determines heading). Humans are very accurate at detecting focus of expansion.

Land and Lee measured eye-position while driving and found people don't look at focus of expansion – concluded that other cues are used in driving besides optic flow,

Loomis et al. showed that you can navigate with your eyes closed (duh).

Lee and Aronson showed that optic flow can affect posture and balance when not associated with actual movement.

Physiology of navigation.

MST contains neurons sensitive to expansion, contraction and rotation.

Britten and van Wezel showed that microstimulating MST affects decisions about optic flow.

Hippocampus and parahippocampal gyrus is associated with navigation:

Maguire et al. used PET to activate hippocampus and parietal cortex while navigating a virtual town.

Jansen and Turnout showed greater fMRI activity in parahippocampal gyrus while recalling objects associated with landmarks during a learning task.

Kanwisher and colleagues named the parahippocampal place area (PPA) because it responds to scenes and locations, but not objects.

London taxi drivers have larger hippocampi.

Other miscellaneous stuff about neurons associated with action in the monkey:

Parietal neurons may respond to vision, motor, or both.

Parietal reach neurons can start responding 200 msec before an action.

Mirror neurons in the premotor cortex respond to monkey's action, or an equivalent human action that the monkey is watching. May play a role in learning by watching, social processes like empathy, and may even be involved with autism.

Chapter 11: Sound, the Auditory System, and Pitch Perception

Sound: waves of (air) pressure differences propagating across space

Sinusoidal 'pure' tones – the simplest sound. Defined by *amplitude* and *frequency*.

Amplitude: associated with the psychological perception of loudness
The decibel measure of loudness is a logarithmic transformation of amplitude. (Doubling the amplitude increases loudness by about 6 decibels)
Decibels scale almost linearly with perceived loudness magnitude estimates.
Frequency: associated with psychological dimension of pitch
The music scale: doubling the frequency increases pitch by one octave
Our scale has 12 equally spaced notes in an octave, 7 are used in a scale
Why 12? It happens to approximate many of the consonant ratios.
Range of hearing:
We can hear sounds between 20 and 20,000 Hz. Dogs up to 40KHz, cats 50KHz and dolphins 150 KHz.
Amplitude thresholds for detection and feeling vary with frequency.
Lowest in intermediate frequency range (1000-5000Hz)
Equal loudness curves are flatter across frequencies for louder sounds.
Timbre: psychological dimension that describes everything but loudness and pitch
Created by adding multiple pure tones together.

Missing fundamental: removing lowest (fundamental) frequency goes unnoticed.
Psychophysical measurements of frequency tuning
Masking experiments show that tones interfere with each other only within a narrow range: evidence of narrowly tuned filters for frequency.

Physiology of audition: the Ear
1) Outer ear: The Pinna and auditory canal – has resonant frequency 2000-5000Hz
2) Middle ear: name the ossicles: Malleus, Incus and Stapes. Form a lever system that amplifies force from the tympanic membrane (eardrum) to the oval window. Leverage needed because other side of oval window contains cochlear fluid.
3) Inner ear: Name the parts: Cochlea: basilar membrane, Scala vestibule, Scala tympani, cochlear partition, oval window, auditory nerve, organ of corti, inner and outer hair cells, tectorial membrane,
Basilar membrane vibrates in response to sound, tectorial membrane amplifies motion by lever action and helps move the inner hair cells.

How is frequency encoded? *Which* fibers respond vs. *how* they respond to different frequencies.
1) Place Theory (Which fibers respond to frequencies) by Von Bekesy:
Low frequencies vibrate apex of basilar membrane, high frequencies vibrate the base. Caused by differences in the width and stiffness of basilar membrane from base to apex. Point of maximal displacement encodes frequency.
Updating place theory: healthy basilar membranes show more specificity to frequency, partly caused by action of the outer hair cells.
Basilar membrane is a frequency analyzer - by vibrating in different places, it breaks down a complex sound in to its component frequencies.
2) Phase locking (How fibers respond to frequencies)
Bursting of firing of nerve cells occurs at peaks of vibrations – so timing encodes frequency.
Physiology of audition: the cortex:
Pathway from cochlea to cortex: auditory nerve fibers -> cochlear nucleus -> superior olivary nucleus -> inferior colliculus -> medial geniculate nucleus -> auditory receiving area (A1) in the cortex. And this is the simplified version!
Auditory areas of cortex
Core -> belt -> parabelt (like V1, V2, etc in vision)
Belt and parabelt respond to more complex stimuli.
Auditory system also has what (ventral) and where (dorsal) pathways.
what' pathway for identifying sounds.
'where' for localizing sounds.

Tonotopic maps in A1: map of neurons responding to successive frequencies.
Training can affect tonotonic maps in owl monkeys.
Musicians have larger auditory cortices.
Neurons in Marmosets trained on one pure change their tuning for hours after testing.

Cochlear implants: electronic device that stimulates the cochlea in the deaf.
Technology improving – becoming very effective if implanted early.