Lecture #08 Cerebral Cortex Sensory Systems

Question 1: Second order axons from the ventral cochlear nuclei project mainly to which structure to process lateralization (left-right azimuthal direction) of low frequency sounds?

a) Medial superior olive

b) Inferior colliculus

c) Dorsal cochlear nuclei

d) Superior colliculus

e) Lateral superior olive

HINT:

Trace the main auditory pathway through three brainstem relays

EXPLANATION:

The cochlea sends primary auditory axons to the ipsilateral cochlear nuclei in the caudal pons (and rostral medulla). Second order cochlear neurons project bilaterally to superior olivary nuclei. The medial superior olive processes interaural time of sound arrival differences from the two ears to lateralize low frequency sounds. The lateral superior olive processes interaural level difference to lateralize high frequency sounds(intensity).

ANSWER: ['Medial superior olive']

Lecture #08 Cerebral Cortex Sensory Systems

Question 2: Which is the gustatory nucleus?

a) Dorsomedial (medial dorsal) nucleus

b) Dorsolateral (lateral dorsal) nucleus

c) Rostral solitary nucleus

d) Rostral salivatory nucleus

e) Ventral postero-lateral nucleus (VPL)

HINT:

The gustatory receiving area has two names, one a functional description, the other an anatomical description

EXPLANATION:

The gustatory receiving area has two names, one a functional description, the other an anatomical description. The facial, glossopharyngeal, and vagus nerves carry taste sensations ipsilaterally into the rostral nucleus of the solitary tract, or gustatory nucleus. Gustatory nucleus secondary neurons project ipsilaterally to the ventral posteromedial nucleus (VPM) of the thalamus, which projects ipsilaterally to gustatory areas of cortex.

ANSWER: ['Rostral solitary nucleus']

Lecture #08 Cerebral Cortex Sensory Systems

Question 3: What does the medial superior olive help discriminate?

a) meaning of speech sounds

b) pitch of sounds

c) potentially toxic odors

d) direction of sounds

e) sequence of musical notes

HINT:

The medial and lateral superior olive process different pitch ranges

EXPLANATION:

Second order cochlear nucleus auditory neurons project bilaterally to superior olivary nuclei. The medial superior olive processes interaural time of sound arrival differences from the two ears to lateralize low frequency sounds, determining their horizontal (azimuthal) direction. The lateral superior olive processes interaural level (loudness or intensity) difference to lateralize high frequency sounds.

ANSWER: ['direction of sounds']

Lecture #08 Cerebral Cortex Sensory Systems

Question 4: The ascending axons from the medial and lateral superior olive directly project mainly to which structure?

a) Inferior colliculus

b) Inferior brachium

c) Superior colliculus

d) Cochlear nuclei

e) Superior brachium

HINT:

Superior olive output goes to the midbrain

EXPLANATION:

The cochlea sends primary auditory axons to the ipsilateral cochlear nuclei in the caudal pons (and rostral medulla). Second order cochlear neurons project bilaterally to superior olivary nuclei. Superior olivary nuclei project to the inferior colliculus, which in turn projects to the medial geniculate nucleus of the thalamus.

ANSWER: ['Inferior colliculus']

Lecture #08 Cerebral Cortex Sensory Systems

Question 5: Which area(s) is (are) specialized for proprioception?

a) Mesencephalic nucleus, Brodmann's area 3a

b) Left parietal cortex

c) Dorsolateral and central amygdala

d) Lateral horn, intermediolateral cell column

e) Heschl's gyrus

HINT:

The proprioceptive receiving area of cortex lies on the parietal bank of the central sulcus as part of primary somatic sensory cortex

EXPLANATION:

Two brain areas are most directly identified with proprioception. In the primary somatic sensory cortex, Brodmann’s areas 3, 1, 2, area 3a selectively receives proprioceptive input. Area 3b gets cutaneous input. Proprioceptors of the face have a separate trigeminal path. Large fiber type A-beta somatic sense axons for touch, pressure, and vibration from the face project to the main (or chief, or principal) sensory nucleus. The largest A-alpha proprioceptor axons project to the mesencephalic nucleus of the trigeminal, where their primary cell bodies lie. All the other primary pseudounipolar cell bodies lie in peripheral ganglia.

ANSWER: ["Mesencephalic nucleus, Brodmann's area 3a"]

Lecture #08 Cerebral Cortex Sensory Systems

Question 6: Which visual deficit is most likely to follow left temporal lobe damage?

a) Left hemispatial neglect

b) Left upper field quadrantanopsia (pie-in-the-sky loss)

c) Right hemispatial neglect

d) Blindness for lower right visual field

e) Right upper field quadrantanopsia (pie-in-the-sky loss)

HINT:

Think about pie

EXPLANATION:

The projection of contralateral visual hemifield to occipital cortex from the lateral geniculate nucleus (LGN) maintains a retinotopic (topographic) layout. The fovea is represented at the occipital pole, the upper visual field (lower retina) is represented on the lower bank of the calcarine sulcus, also called lingual cortex, and the lower visual field is represented on the upper bank of the calcarine sulcus, also called the cuneus. The upper field axons take Meyer’s loop through the temporal lobe. Damage to Meyer’s loop produces a contralateral upper field quadrantanopsia, or pie-in-the-sky visual field loss. The lower field axons pass directly back via the parietal lobe.

ANSWER: ['Right upper field quadrantanopsia (pie-in-the-sky loss)']

Lecture #08 Cerebral Cortex Sensory Systems

Question 7: What is Meyer's loop?

a) The re-decussation of the dorsal spinocerebellar tract so that it ends ipsilaterally in the cerebellum despite having a mainly contralateral course

b) The temporal course of upper visual hemifield optic radiations destined for the lower bank of the calcarine sulcus

c) The axons responsible for hole-in-the-pole or hole in the donut blindness for objects straight ahead with intact peripheral vision

d) The re-decussation of the ventral spinocerebellar tract so that it ends ipsilaterally in the cerebellum despite having a mainly contralateral course

e) The limbic pathway that originates in cerebral cortex and passes through a series of limbic structures to return to cerebral cortex

HINT:

Meyer’s loop damage is often accompanied by ventral visual stream loss

EXPLANATION:

The optic radiations from the LGN split into a temporally directed upper visual quadrant component that follows “Meyer’s loop” through the temporal lobe to reach the lower bank of the calcarine sulcus, and a parietally directed lower visual quadrant component that takes a more medial direct path to reach the upper bank of the calcarine sulcus.

ANSWER: ['The temporal course of upper visual hemifield optic radiations destined for the lower bank of the calcarine sulcus']

Lecture #08 Cerebral Cortex Sensory Systems

Question 8: Which best distinguishes the olfactory paths from other sensory paths?

a) They do not involve cranial nerves

b) They are contralateral

c) They project to paleocortex

d) They have a thalamic relay

e) They remain ipsilateral

HINT:

consider laterality of projections

EXPLANATION:

Primary olfactory cortex is in ventral frontal and temporal paleocortex. Olfaction is the only sense that requires no thalamic relay and projects to paleocortex. Primary visual cortex area V1 is in the occipital lobe, area 17, striate cortex, or calcarine cortex. Primary somatic cortex S1 (including proprioceptive inputs to area 3a) is on the postcentral gyrus, areas 3, 1, and 2 of the anterior parietal lobe. Primary auditory cortex, Heschl’s gyrus, is in the medial temporal lobe.

ANSWER: ['They project to paleocortex']

Lecture #08 Cerebral Cortex Sensory Systems

Question 9: Which is the next step on the dorsal visual stream beyond the first or second visual area?

a) Cingulate cortex (areas 17 and 18)

b) Amygdala

c) Middle temporal area (MT)

d) Color area (V4)

e) Hippocampus (CA1-CA3)

HINT:

Its name suggests a ventral stream destination

EXPLANATION:

Calcarine layer 4 magnocellular information is projected to the middle temporal area (MT), directly and via the second visual area V2. Parvocellular information from calcarine cortex is projected to the color area V4 via area V2. Ultimately, magnocellular information is sent to parietal cortex and is used to guide movement. Ultimately, parvocellular information is sent to inferotemporal and fusiform occipito-temporal cortex and is used for visual form perception. The magnocellular pathway is also called the parietal, dorsal, ‘what,’ or action visual stream. The parvocellular pathway is also called the temporal, ventral, ‘where,’ or form perception stream.

ANSWER: ['Middle temporal area (MT)']

Lecture #08 Cerebral Cortex Sensory Systems

Question 10: Which is a feature of topographic organization of neocortex?

a) Frontal, temporal, and parietal lobes have topographically organized areas, but occipital lobes do not

b) The trunk and belly tend to have disproportionately large representations in somatic maps

c) Cortical topographic maps usually represent the ipsilateral body half only

d) Sizes are precisely represented as equivalent sizes on topographic maps

e) Body parts with more detailed sensation or more sensory receptors are allotted a disproportionately large portion of somatic sensory cortex, distorting the maps

HINT:

This feature of topographic organization is apparent in both visual and somatic sense

EXPLANATION:

Topographic sensory maps are widespread across senses and animal species. The hands, face, and feet have an exceptionally large area of representation on primary somatic sensory cortex, in accordance with their dense innervation and functions. The fovea has a greatly enlarged representation on occipital cortex, facilitating acute foveal vision.

ANSWER: ['Body parts with more detailed sensation or more sensory receptors are allotted a disproportionately large portion of somatic sensory cortex, distorting the maps']

Lecture #08 Cerebral Cortex Sensory Systems

Question 11: Which area is known for having visual feature detectors?

a) Meyer's loop

b) Calcarine cortex

c) Prefrontal cortex

d) Middle temporal area (MT)

e) Inferotemporal cortex

HINT:

Feature detectors include monkey hand detectors and other simple meaningful object shape detectors

EXPLANATION:

parvocellular information is sent to inferotemporal and fusiform occipito-temporal cortex and is used for visual form perception. Inferotemporal cortex neurons include ‘feature detectors’ for meaningful shapes. Fusiform cortex neurons include ‘face detectors’ for recognition of familiar faces. The parvocellular pathway is also called the temporal, ventral, ‘where,’ or form perception stream.

ANSWER: ['Inferotemporal cortex']

Lecture #08 Cerebral Cortex Sensory Systems

Question 12: Which best distinguishes the gustatory paths from other sensory paths?

a) They are contralateral

b) They project to paleocortex

c) They do not involve cranial nerves

d) They remain ipsilateral

e) They have a thalamic relay

HINT:

Gustatory sense of taste should not be confused with olfactory sense of smell; flavors are a combination of olfaction and gustation

EXPLANATION:

The facial, glossopharyngeal, and vagus nerves carry taste sensations ipsilaterally into the rostral nucleus of the solitary tract, or gustatory nucleus. Gustatory nucleus secondary neurons project ipsilaterally to the ventral posteromedial nucleus (VPM) of the thalamus, which projects ipsilaterally to gustatory areas of cortex. This is the most directly ipsilateral of the sensory paths.

ANSWER: ['They remain ipsilateral']

Lecture #08 Cerebral Cortex Sensory Systems

Question 13: Damage to the cuneus of the occipital lobe causes which deficit?

a) A specific blindness from which there is only partial recovery

b) Permanent scotoma in contralateral lower visual field quadrant

c) Temporary scotoma in contralateral lower visual field quadrant

d) Temporary scotoma in contralateral upper visual field quadrant

e) Permanent scotoma in contralateral upper visual field quadrant

HINT:

Upper, lower, and posterior retina are mapped to upper, lower, and posterior calcarine cortex

EXPLANATION:

Damage to the calcarine map produces permanent blind regions of the visual field. Damage to all of one calcarine cortex produces a blindness of the contralateral visual hemifield. Damage to the occipital pole can cause foveal blindness and loss of acuity, though there may be retained vision called macular sparing. Damage to the cuneus causes a contralateral lower field quadrantanopia (quadrantanopsia). Damage to the lingual cortex causes a contralateral upper field quadrantanopia. Damage to the temporal Meyer’s loop geniculocortical axons that project to the lingual cortex can produce a similar pie-in-the-sky blind region. Blind areas are also called scotomas (scotomata) or field cuts.

ANSWER: ['Permanent scotoma in contralateral lower visual field quadrant']

Lecture #08 Cerebral Cortex Sensory Systems

Question 14: What body part occupies the largest part of rodent somatic sensory cortex?

a) Feet (hindpaws)

b) Hands (forepaws)

c) Sex organs

d) Mouth

e) Whiskers (vibrissae)

HINT:

Rodents rely less on sight and sound than humans do

EXPLANATION:

More densely innervated and more important parts of sensory inputs have an expanded representation on sensory cortex. The fovea is only a tiny portion of our visual field of view, yet much of calcarine primary visual cortex is devoted to the fovea. Similarly, the homunculus on human somatic sensory cortex has a greatly enlarged representation of the face, especially the mouth, and of the hands, with very little area devoted to the trunk. Rodents rely on their vibrissae, facial whiskers, for much of their exploration of the environment. The vibrissae representation is much of rodent somatic sensory cortex. Each vibrissa has a devoted barrel area of cortical neurons that process information from that one whisker. The barrel fields are the distinctive feature of rodent somatic sensory cortex.

ANSWER: ['Whiskers (vibrissae)']

Lecture #08 Cerebral Cortex Sensory Systems

Question 15: What is the function of the lateral superior olive?

a) Projection of mossy fibers to the cerebellum

b) Processing direction of high frequency sounds

c) Relaying large fiber somatic sensory information

d) Processing sweet and bitter taste sensations

e) Projection of climbing fibers to the cerebellum

HINT:

The lateral superior olive has a function complementary to that of the medial superior olive

EXPLANATION:

The cochlea sends primary auditory axons to the ipsilateral cochlear nuclei in the caudal pons (and rostral medulla). Second order cochlear neurons project bilaterally to superior olivary nuclei. The medial superior olive processes interaural time of sound arrival differences from the two ears to lateralize low frequency sounds. The lateral superior olive processes interaural level difference to lateralize high frequency sounds (intensity).

ANSWER: ['Processing direction of high frequency sounds']

Lecture #08 Cerebral Cortex Sensory Systems

Question 16: Where is the fovea represented in calcarine (occipital) cortex?

a) Along the fundus

b) Lower bank

c) Anterior

d) Upper bank

e) Posterior

HINT:

Upper, lower, and posterior retina are mapped to upper, lower, and posterior calcarine cortex

EXPLANATION:

Each calcarine cortex maps the contralateral visual hemifield. Damage to the calcarine map produces permanent blind regions of the visual field. Upper, lower, and posterior retina are mapped to upper, lower, and posterior calcarine cortex. The cuneus maps the lower visual field (upper retina). The lingual cortex maps the upper visual field (lower retina). The fovea is represented over a very large area around the occipital pole of the brain, with the map proceeding peripherally in the anterior direction forward from the pole. The far visual periphery is represented most anteriorly. The horizontal meridian (horizon) lies along the fundus (bottom) of the calcarine fissure. The vertical meridian (vertical midline) is the dividing line between the two visual hemifields and the two cortical hemispheres. The two calcarine cortices are joined at the vertical meridian by axons that pass through the splenium of the corpus callosum. Damage to all of one calcarine cortex produces a blindness of the contralateral visual hemifield. Damage to the occipital pole can cause foveal blindness and loss of acuity, though there may be retained vision called macular sparing. Damage to the cuneus causes a contralateral lower field quadrantanopia (quadrantanopsia). Damage to the lingual cortex causes a contralateral upper field quadrantanopia. Damage to the temporal Meyer’s loop geniculocortical axons that project to the lingual cortex can produce a similar pie-in-the-sky blind region. Blind areas are also called scotomas (scotomata) or field cuts.

ANSWER: ['Posterior']

Lecture #08 Cerebral Cortex Sensory Systems

Question 17: Where are the secondary neurons of the gustatory pathway located?

a) Medial superior olive

b) Lateral superior olive

c) Caudal solitary nucleus

d) Rostral solitary nucleus

e) Inferior olive

HINT:

The gustatory receiving area has two names, one a functional description, the other an anatomical description

EXPLANATION:

The facial, glossopharyngeal, and vagus nerves carry taste sensations ipsilaterally into the rostral nucleus of the solitary tract, or gustatory nucleus. Gustatory nucleus secondary neurons project ipsilaterally to the ventral posteromedial nucleus (VPM) of the thalamus, which projects ipsilaterally to gustatory areas of cortex.

ANSWER: ['Rostral solitary nucleus']

Lecture #08 Cerebral Cortex Sensory Systems

Question 18: Damage to which structure(s) results in loss of pitch sequence discrimination (cannot name that tune)?

a) Heschl's gyrus (or gyri)

b) Medial geniculate nucleus

c) Superior colliculus

d) Cochlear nuclei

e) Inferior colliculus

HINT:

Pitch sequence discrimination is a cortical function

EXPLANATION:

Brainstem auditory centers are sufficient for simple pitch discrimination, discriminating different pitches from each other. However, the auditory cortex of Heschl’s gyrus and beyond is required for discrimination of pitch sequences and more complex auditory discriminations such as voice and language recognition.

ANSWER: ["Heschl's gyrus (or gyri)"]

Lecture #08 Cerebral Cortex Sensory Systems

Question 19: Damage to which structure(s) results in ipsilateral hearing loss?

a) Superior colliculus

b) Inferior colliculus

c) Heschl's gyrus (or gyri)

d) Medial geniculate nucleus

e) Cochlear nuclei

HINT:

Only one relay along the auditory path has information from a single ear

EXPLANATION:

The cochlea sends primary auditory axons to the ipsilateral cochlear nuclei in the caudal pons (and rostral medulla). The cochlear nuclei are the only auditory relay nuclei that are monoaural and ipsilateral. All further relays are binaural, bilateral. Second order cochlear neurons project bilaterally to superior olivary nuclei. The medial superior olive processes interaural time of sound arrival differences from the two ears to lateralize low frequency sounds. The lateral superior olive processes interaural level difference to lateralize high frequency sounds (intensity). Superior olivary nuclei project to the inferior colliculi. The commissure of the inferior colliculus interconnects the two colliculi for more binocular processing. The inferior colliculi project to the medial geniculate nuclei, which project to primary auditory cortex of Heschl’s gyrus. The corpus callosum interconnects the two Heschl’s gyri.

ANSWER: ['Cochlear nuclei']

Lecture #08 Cerebral Cortex Sensory Systems

Question 20: Which is the next step on the ventral visual stream beyond the first or second visual area?

a) Color area (V4)

b) Middle temporal area (MT)

c) Cingulate cortex (areas 17 and 18)

d) Hippocampus (CA1-CA3)

e) Amygdala

HINT:

It is named for a quality important to perception

EXPLANATION:

Parvocellular information from calcarine cortex is projected to the color area V4 via area V2. Ultimately, magnocellular information is sent to parietal cortex and is used to guide movement. Ultimately, parvocellular information is sent to inferotemporal and fusiform occipito-temporal cortex and is used for visual form perception. The magnocellular pathway is also called the parietal, dorsal, ‘what,’ or action visual stream. The parvocellular pathway is also called the temporal, ventral, ‘where,’ or form perception stream.

ANSWER: ['Color area (V4)']

Lecture #08 Cerebral Cortex Sensory Systems

Question 21: What body part is represented most laterally in human somatic sensory cortex?

a) Mouth

b) Feet

c) Sex organs

d) Hands

e) Trunk

HINT:

Bilateral damage to the medial walls of the postcentral gyri affect lower limb sensations

EXPLANATION:

The human somatic sensory cortex area 3,1,2 has a clearly defined homunculus, a topographic map that represents the contralateral half of the body. Beginning in the interhemispheric fissure, the feet and legs are represented on the medial wall and dorsomedial surface of the postcentral gyrus, then the trunk has a small representation, then the arm, followed laterally by a very large hand and fingers representation. The face is most lateral, with an enlarged representation of the lower face, and especially the mouth, most laterally and ventrally located on the postcentral gyrus.

ANSWER: ['Mouth']

Lecture #08 Cerebral Cortex Sensory Systems

Question 22: How are the magnocellular and parvocellular visual paths organized in the LGN?

a) Magnocellular axons project to LGN layers 1 and 2, parvocellular axons to layers 3-6

b) Magnocellular axons project rostrally in the LGN, parvocellular axons caudally

c) Magnocellular axons project along projection lines, parvocellular axons are off-line

d) Magnocellular axons project to the left LGN, parvocellular axons to the right LGN

e) A projection line contains axons from only one or the other path, not both

HINT:

Magnocellular and parvocellular visual pathways are separate from retina through cortex

EXPLANATION:

Magnocellular parasol retinal ganglion cells send axons to lateral geniculate nucleus (LGN) layers 1 and 2, the magnocellular LGN layers. Parvocellular midget retinal ganglion cells send axons to LGN layers 3-6, the parvocellular LGN layers. Magnocellular and parvocellular projections from LGN to calcarine cortex synapse in separate sub-layers in layer 4. Calcarine layer 4 magnocellular information is projected to the middle temporal area (MT), directly and via the second visual area V2. Parvocellular information from calcarine cortex is projected to the color area V4 via area V2. Ultimately, magnocellular information is sent to parietal cortex and is used to guide movement. Ultimately, parvocellular information is sent to inferotemporal and fusiform occipito-temporal cortex and is used for visual form perception. The magnocellular pathway is also called the parietal, dorsal, ‘what,’ or action visual stream. The parvocellular pathway is also called the temporal, ventral, ‘where,’ or form perception stream.

ANSWER: ['Magnocellular axons project to LGN layers 1 and 2, parvocellular axons to layers 3-6']