COGS 160: Brain Waves  
Midterm II: Due In Class Friday 5/19

Name: ________________________________________________________________

1. Which of the following functions is often associated with the alpha rhythm? (2 points)
   
   A. Maintaining an active neural assembly over time (status quo)
   B. Filtering out irrelevant information
   C. Reorganizing cortical networks
   D. Packaging information to be sent to other brain regions

2. Identify the network that exhibits sharp wave ripples (2 points):
   
   A. Thalamocortical loops
   B. The CA3 and CA1 subregions of the hippocampus
   C. The basal ganglia and motor cortex
   D. Visual cortex

3. The theta rhythm is often observed in the hippocampus during (2 points):
   
   A. Periods of active exploration (e.g. a spatial navigation task)
   B. Sustained muscle contraction (e.g. a grip task)
   C. Periods of rest or immobility (e.g. slow wave sleep)
   D. None of the above

4. Which of the following would NOT result in increased alpha activity (2 points):
   
   A. Propofol anesthesia
   B. Eye-closing
   C. Ignoring a visual stimulus
   D. Hyperpolarizing a single thalamocortical neuron

5. Two visual stimuli, Stimulus A and Stimulus B, are simultaneously presented at distinct, moderately distant locations on a screen. A subject is informed to attend to a color change that occurs in Stimulus A.
   
   A. A group of neurons (Group A) in visual cortex exhibits activity in response to the presentation of Stimulus A. In which rhythm will Group A likely exhibit synchronous activity? Provide the name and the frequency range. (2 points)

   One point was given for identifying the gamma rhythm and one point was given for naming a frequency range within roughly 30-90Hz
B. A separate population of neurons (Group B) in visual cortex is responsive to
**Stimulus B.** Compare the degree of synchrony you would expect to see in Group A
versus Group B. (4 points)

Two points were awarded for identifying that the activity of Group A is more synchronous than Group
B. This is because Group A is responsive to an attended stimulus while Group B is responsive to an
unattended stimulus.

C. Group A and Group B send projections to the same population of neurons in
another brain region (Group C). If Group A and Group B are not synchronous with
each other, with which group is Group C likely to be coherent? Justify your answer.
(4 points)

Two points were awarded for identifying that Group C is likely to be coherent with Group A. Two
additional points were awarded for indicating that a population exhibiting more synchronous activity is
likely to more effectively elicit spiking activity in a downstream network.

6. A monkey is instructed to maintain a grip and then release a lever while local field
potential activity is recorded from motor cortex.
A. What rhythm would you expect to see in motor cortex during this task? Identify the
name of the rhythm and the frequency range. (2 points)

One point was given for identifying the beta rhythm and one point was given for naming a frequency
range roughly between 15-30 Hz.

B. How would you expect the amplitude of the rhythm to change as the monkey
maintains the grip and then releases the lever (4 points)?

Two points were awarded for indicating that the amplitude of the beta rhythm should increase as the
monkey grips a lever, and two points were awarded for indicating that the amplitude should decrease
when the lever is released.

C. How does this activity support or contradict theories regarding the function of the
beta rhythm (4 points)?

Two points were awarded for indicating that beta rhythm is thought to maintain the activity of neural
assemblies over time (or status quo). Two additional points were awarded if students a) referenced the
persistence of a large amplitude beta rhythm during sustained contractions (and its disappearance
during release) as evidence supporting this function OR b) provided a logical justification for why the
dynamics of the beta rhythm appear inconsistent with this function.
7. During slow wave sleep, neurons in the cortex demonstrate a characteristic activity profile.
   A. Describe neural spiking activity in the cortex during cortical UP and DOWN states (2 points).
      One point was awarded for identifying that there are increases in cortical activity during UP states, and one point was awarded for indicating that DOWN states are periods of relative quiescence.
   B. Describe a process that slow waves are hypothesized to mediate during sleep. (4 points)
      Two points were awarded for naming a process associated with slow wave sleep. Acceptable answers could indicate that slow wave sleep facilitates a reorganization of synaptic strengths or memory consolidation. Two additional points were given for correctly describing the process (e.g. a strengthening or weakening of synapses).
   C. Describe the results of an experiment investigating the potential function of slow waves during sleep, and explain how the results support or contradict the hypothesized function described in part B. (4 points)
      Two points were given for identifying an experiment that examined slow wave sleep and describing the results. Two additional points were given if students indicated how the results of the experiment support or contradict current hypotheses regarding its association with certain processes.

8. Region X and Region Y are connected cortical brain regions that both exhibit beta frequency oscillations during a task in which a monkey simultaneously looks at a visual target on a screen and reaches for an object directly in front of them.
   A. The beta oscillations in both regions appear to be coherent during periods before the monkey initiates a coordinated saccade and reach. Describe the theory of communication through coherence, and explain what the theory would suggest about interactions between Region X and Region Y. (6 points)
      Two points were awarded for mentioning the communication through coherence hypothesis suggests that there are optimal (or non-optimal) times for communication.
      Two points were awarded for mentioning that interactions between networks must be temporally coordinated.
      Two points were awarded for indicating that the simultaneous, coherent beta oscillations might indicate that they are able to directly communicate.
   B. It is recently discovered that a subcortical region of the brain, which sends projections to both Region X and Region Y, also exhibits synchronized beta oscillations with both regions during the simultaneous saccade and reach task. Develop two hypotheses regarding the potential interactions between the three brain regions that are consistent with the observed coherence. (4 points)
      Two points were awarded for each hypothesis. Acceptable answers could include the following:
      a) All three regions are directly interacting and involved in cooperative processing.
      b) The two cortical regions are not directly interacting, but they are involved in cooperative processing through their interactions with the subcortical region.
      c) The two cortical regions are not directly interacting, and are involved in independent processes.
Choose your own adventure: answer three of the four remaining exam questions (9-12). The fourth question you may choose to answer for extra credit.

9. During some rhythms, a sequence of neural activity that occurred during a behavior will occur in a temporally compressed manner within a single cycle of the rhythm. Provide the name of a rhythm that can demonstrate this phenomenon, its frequency range, the brain region where it is recorded, and the behavior of the organism at the time the phenomenon occurs. (4 points)

   One point was awarded for naming either slow wave sleep, the theta rhythm, or sharp wave ripples.
   One point was awarded for naming the correct frequency range.
   One point was awarded for naming the brain region where the compressed neural activity is recorded
   (e.g. cortex, hippocampus).
   One point was awarded for naming the behavior of the organism at the time of the compressed sequence (e.g. sleep, active exploration, or immobility)

10. A subject is told to attend to a location in their left visual field where a visual stimulus will soon appear. A visual stimulus will also appear in their right visual field, but they are told to ignore it. In which area of the brain are you likely to see an elevated alpha rhythm? Justify your answer. (4 points)

   Two points were awarded for identifying that an elevated alpha rhythm will appear in visual cortex.
   Two points were awarded for identifying that an elevated alpha will be observed in an area that is responsive to the right visual field (the LEFT visual cortex).

11. Describe how inhibitory neurons within PING networks can facilitate the creation of optimal and non-optimal windows for communication between two brain regions (4 points)

   Four points were awarded for indicating that interneurons cause IPSPs in other neurons (suppress), creating time windows when they are less likely to exhibit an action potential. Optimal windows occur when the inhibition to wears off.

12. Describe the hypothesized function of the theta rhythm in facilitating communication between the hippocampus and other brain regions. In addition, hypothesize what communication in words and sentences would resemble without successful execution of this function. (4 points)

   Two points were awarded for indicating that the theta rhythm is hypothesized to package information to be sent to other brain regions. If students described coherence between the hippocampus and the mPFC, this was also acceptable. Two additional points were awarded for describing a scenario in which there was no packaging of information in language (e.g., no spaces or pauses between words, run-on sentences).