CompSci 182 / CogSci 110 / Ling 109
Midterm Examination, Spring 2006
Prof. Srini Narayanan

Name: ______________________________ SID: ____________ Comp(Y/N): ___ Section: _______

	1	2	3	4	5	Total
Score						/50

1. (10 points total) Briefly justify your answers

   (a) (3 points) Why is Hebbian learning not a complete story for how we learn generally?

   (b) (3 points) How does it work biologically?

   (c) (2 points) What is a triangle node in connectionist modeling?

   (d) (2 points) Describe an implementation of a triangle node using abstract neurons with a binary threshold activation function.

Students in the Computation option SKIP this question

2. (10 points total)

   Consider a behavioral experiment that is being designed to test the hypothesis that processing action words activates brain circuits that are used for performing the action described. The task is a picture-word matching task. Each subject is presented with a picture of a motor action (kick, chew, grasp) followed by a word (an English verb). The task is to determine if the word correctly describes the action in the picture and to press "yes" if it does and "no" if it doesn't.

   The picture stimulus is on for 1 second followed by a 500 millisecond interval where a fixation cross is shown. An English verb in written form is then presented until the subject presses a button indicating that the verb is or is not a good description for the action depicted in the image. Reaction times for the response are measured and used to test the hypothesis. The type of word stimulus presented falls into three conditions

   (a) **matching** where the word describes the action in the picture,

   (b) **mismatch same effector** where the word describes a different action than the picture but uses the same effector (body part). An example of this condition is the pairing of the picture of *walk* followed by the word *kick*.

   (c) **mismatch different effector** where the picture and word do not match and use different body parts. An example is the pairing of the picture of *walk* followed by the word *scratch*.

   The pictures and words are chosen from 3 effectors (foot, hand, and mouth). At the end of the experiment, for each subject, their reaction times are measured and grouped into the three conditions described above for comparison: (1) matching picture and word, (2) mismatch with the same effector (3) mismatch with different effectors.

   (a) (4 Points) What is somatotopy? How did the Buccino et al.(2001) fMRI mirror neuron experiment relate the somatotopic organization of the premotor cortex to observing actions involving different body parts?

   (b) (4 Points) Given the various results presented in class, would you predict greater reaction time results for the **mismatch same effector** condition or the **mismatch different effector** condition? Explain your answer.

   (c) (2 points) Why did the experiment add a 500 millisecond fixation cross between the picture and the word? (Hint: Would it have worked if the interval was 100 milliseconds?)

Students in Computational option DO this question

Consider the special Γ subclass of PDP neural networks. A Γ network has an input layer (indexed by i), a hidden layer (indexed by h) and an output layer (indexed by o). With these networks, we will use the letter a to refer to a node's activation. For example, a_o would be the activation of a node in the output layer. We will use t_o to refer to an output node's target value. To refer to the weight of an edge between the hidden and output layer, we will use w_{ho} and for the input to hidden, w_{ih}.

In a Γ network, the activation function of an output node is of the form $a_o = K * \sum_h (w_{ho} * a_h)$ and the activation function of a hidden node is $a_h = K * \sum_i (w_{ih} * a_i)$ where K is the same real number for all activation functions in the network.

For Γ networks:

(a) (2 Points) What is the derivative of the error function with respect to w_{ho}?

(b) (2 Points) Ignoring momentum and assuming a learning rate of α, show the weight update function for w_{ho}

(c) (2 Points) What is the derivative of the error function with respect to w_{ih}?

(d) (2 Points) Rewrite the activation function for an output node of a Γ net without reference to a_h.

(e) (2 Points) What does the result from the previous part suggest about the class of problems that Γ networks can solve?

3. (10 points total) Consider the following concepts:

    - clothing
    - to amble
    - a bike
    - the color maroon

    (a) (6 points) Discuss for each concept whether it is a basic-level, superordinate or subordinate category. Support your answers with relevant criteria.

    (b) (4 points) From the lectures and readings covered in class, what can you say about how each of these concepts may be embodied in the neural circuitry of the brain. Be concise in your answer.

4. (10 Points total)

(a) (2 Points) Why is Regier's program an example of embodied semantics?

Regier's model was predicated on the premise that our learning and understanding of spatial-relation terms is necessarily grounded in our basic sensory-motor circuits and our interactions with the world. Specifically, the model used image schemas as the computational primitives, and learned spatial relations as operations over them.

(b) (2 Points) Specify two limitations of Regier's program.

The model can't scale up to other linguistic domains; has no handle on grammar; can't do language production; is not provably the unique solution to the problem of learning spatial relations (i.e. it's only an "existence proof"); can't perform inference ("if x is to the right of y then y is to the left of x"); can't learn abstract meanings of spatial terms; and is representationally opaque (since it's PDP).

(c) (2 Points) Why is the system not able to learn the word *near*?

The model has no primitive distance metric—and it can't deduce distance from the other measurements. In fact, there is no notion at all of size generally.

(d) (4 Points) Why does Regier's program use implicit as opposed to explicit negative evidence? How does the program implement implicit negative evidence?

Human children don't usually get (many) explicit negatives in the course of learning words; i.e., they may get corrected ("No, that's not above, *that's* next to*"), but they aren't simply presented with all instances of words that don't apply ("The block is under the couch, kiddo; not 'next to' or 'above' or 'to the left of' or...."). So it would be cheating to supply the model with explicit negatives to all spatial-relation words that don't apply.*

On the other hand, Regier couldn't simply take positive evidence of one word as implicit negative evidence for all the others, since spatial-relation terms are not mutually exclusive (e.g., above *and* outside *obviously overlap a bit). So instead, he took positive evidence to be—indeed implicit negative evidence for the other words, but down-weighted; or in equations:*

$$E = \frac{1}{2} \sum (t - o)^2 \tag{1}$$

is changed to

$$E = \frac{1}{2} \sum ((t - o)\beta)^2 \tag{2}$$

for negative evidence (i.e. when $t = 0$), where β is a real number on the interval $(0, 1)$.

5. (10 points total)

   (a) (6 points) Give the image-schema analysis of each of these examples. Indicate trajectors and landmarks and draw a diagram or feature structures indicating the bindings for each.

   - ″into″ as in ″The mouse crawled into the box″

   - ″above″ as in ″The balloon is floating above the trees.″

   (b) (4 points) Give an example of an English preposition that involves the *support* schema. Put it in a sentence and justify your answer.