# Cognitive Modeling (2009-2010)

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# Assignment 2

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| Due date: | 01 March, 2010 |
| Weighting: | 10% of total mark |

Please hand in a hardcopy of your solution by 4:00pm on the due date to the Informatics Teaching Organization, Level 4, Appleton Tower. If you have questions regarding the assignment, please contact the lecturer, Sharon Goldwater, at `sgwater@inf.ed.ac.uk`.

**Note that there are two paths through this assignment. One is for CM-4, the 4th year undergraduate version of this course, the other one is for CM-5, the MSc version of this course. Please make sure that you answer the right questions for your level!**

Please remember that plagiarism is a university offense. Do not show your written/coded solutions to anyone else, or try to see anyone else's, and do not discuss the specifics of your solutions with other students (unless otherwise stated for particular questions). However, please also remember that, on any course, you learn as much or more from your peers as you do from your instructors. You should therefore feel free to discuss the general topics surrounding the problems with one another, ideally after you have considered them yourself. But at the end of the day what you write must be yours, and you must understand what you write, and why you didn't write other things. The approach should be one you have chosen to take. If you don't understand it don't write it — it will generally be obvious you don't understand. And if you have questions or problems involving the specifics of your solution, please contact me rather than your fellow students.

## 1 Cohort Model CM-4 + CM-5

Download the following file, which contains the model that you will work with in this assignment: `http://www.inf.ed.ac.uk/teaching/courses/cm/assignments/cm_a02.tar.gz`

Use `gunzip` and `tar` to unpack this file in the `projects` subdirectory of your Cogent directory (this is the user directory you specified during the installation). Upon restarting Cogent, you should see a research program called `Assignment 2` in the Cogent root window. Select this program and doubleclick on the only model within this research program, called `Cohort Model`. This model implements a simple version of the Cohort model which recognizes isolated words only and uses a toy lexicon. It is the same as the implementation presented in class (Lecture 6). Note that the `Access` property of the `Stimuli` buffer is `FIFO`. This doesn't accurately reflect a real experiment (where stimuli would be randomized) but makes the results reproducible and easier to examine.

**Question 1 (10%) CM-4 + CM-5**
What does "bottom-up activation" mean, and which rule is responsible for the bottom-up activation of words in the model?

**Question 2 (10%) CM-4 + CM-5**
What is the recognition point for the word *horse* in this model? How do you think your own recognition point for this word differs from that of the model (if at all), and why? What general prediction does the Cohort theory make about the differences in word recognition points between young children and adults?

**Question 3 (15%) CM-4 + CM-5**
A well-known result in the word recognition literature is that frequent words are recognized faster than infrequent words. What modification to the Cohort model does

Marslen-Wilson (1987) suggest to deal with this? From a rational analysis perspective, why might frequent words be recognized faster than infrequent words?

## 2 Limiting the Cohort CM-4 + CM-5

Although the model we are working with has only a toy lexicon, we can still examine many of the general properties of the Cohort model. This question explores the effects of limiting the capacity of the cohort. Don't modify the original version of the model. Instead, make a copy of the model and name it `Limited Capacity Cohort`.

**Question 4 (15%) CM-4 + CM-5**
Let's assume that the cohort is stored in short-term memory, which has a capacity of 7 elements. How would you simulate this in the model, and what differences does it make to the model's behavior? (You may need to change the contents of the `Stimuli` and/or `Lexicon` buffers to observe differences – describe any changes you made.) Give an example of a stimulus word that exhibits the new behavior, and explain why the behavior occurs. What can you conclude about the cognitive plausibility of storing the cohort in short-term memory?

## 3 Lexical Decision CM-4

Make another copy of the original version of the model to use for this question, and name this one `Lexical Decision Cohort`. This version should not contain any of the changes you made in the previous question. In this question we will modify the model to simulate the lexical decision task.

**Question 5 (5%) CM-4**
When presenting a real word to a human subject, is the recognition point of the word always the same as the point where a decision can be made in the lexical decision task? Explain your answer.

**Question 6 (10%) CM-4**
Add the non-word *bla* at the end of the stimulus list in the model. According to behavioral experiments, how much of this stimulus should the model need to hear before it recognizes that the stimulus is a non-word in the lexical decision task? What does the model actually output for this stimulus, and why? Can you think of other non-words that produce a different kind of incorrect output?

**Question 7 (10%) CM-4**
Explain intuitively how you would need to change the model in order to correctly predict lexical decision points for both words and non-words. Assume that for this task, the model should output either `recognized(nonword,X)` or `recognized(word,X)`, with `X` being the list of phonemes that have been heard at the point when the lexical decision is made.

**Question 8 (25%) CM-4**
Now modify the model to implement the lexical decision task as described in the previous question. Describe the changes you made to the model and what they do.

## 4 Context CM-5

For these questions, you will extend the Cohort model to include a simple context filtering mechanism. Make another copy of the original version of the model to use for this question, and name this one `Context Cohort`. This version should not contain any of the changes you made previously.

The context in this extended model will consist only of very basic syntactic category information. This could correspond to a behavioral experiment in which syntactic context is isolated as much as possible from other contextual information by using semantically vague sentence stimuli such as *Do you want to* __ for a verb context, or *Is that a* __ for a noun context.

Assume that each word in the lexicon is associated with a syntactic category as well as a meaning and a phonemic representation. For example, the word *catch* should be represented in the lexicon as `word(catch, [c,a,t,c,h,.], verb)`. The word *bid* should also be a `verb`; *big* should be an `adj`; all other lexical entries should be `nouns`. Each stimulus in the set of stimuli should also be associated with a syntactic category representing the syntactic context in which the stimulus is presented.

**Question 9 (8%)** **CM-5**
Modify the lexicon and the set of stimuli as described above, assuming for now that all the stimuli are presented in syntactically appropriate contexts. Also modify the rest of the model so that it corresponds to the Cohort model as described in Marslen-Wilson (1987): after the word-initial cohort is activated, words that don't match the stimulus context are filtered out. (Note that you may need to put single quotes around the '.' character when editing rules in order to avoid syntax errors.) Write down any new rules you added to the model and explain what they do. There will be small changes to several other rules; don't bother to list these.

**Question 10 (12%)** **CM-5**
Now consider what happens when you change the stimuli to simulate presenting them in inappropriate contexts. List the new contexts you tried, describe the changes you see in the output of the model for the various stimuli, and explain why they occur. Are there any words that have the same output when presented in appropriate and inappropriate contexts, and if so, why? Comment on the plausibility of the model, with regard to both experimental and natural settings.

# 5 Learning CM-5

Young children are often able to learn words based on a single presentation, a phenomenon called "one-shot learning". For example, if they observe a scene that includes (among other things) a single novel object, and simultaneously hear a sentence that includes a single novel word in a noun context (such as *There's a wug*), they can later answer questions like *What are these?* (referring to two similar objects) by saying *wugs*. This shows that they have learned the meaning of the word, as well as its pronunciation and syntactic category (because only nouns have plurals ending in *-s*).

This question examines the suitability of the Cohort model as a model of word learning. Make a copy of the `Context Cohort` model from the previous question and use it to answer this question.

**Question 11 (30%)** **CM-5**
Modify your context model so that when it hears a novel word, it adds the new word to the lexicon with its associated phonemic and syntactic information. The model should also output `recognized(novel,Word)`, where `Word` is the novel word. Describe the changes you had to make and how the new model works. Also discuss any weaknesses of your model.

## Literature

Marslen-Wilson, W. 1987. Functional parallelism in spoken word-recognition. *Cognition* 25: 71–102.