Introduction to Cognitive Science for Mathematical Scientists

Cognitive Science 050.313/613

Representation Everywhere

Problem Set 10-31

October 31, 2003

Due: Friday, November 7, 2003

This is an open-ended question with no particular right or wrong answers. In fact, I'm not sure I could give a satisfying answer to this one. I don't know how long the answer should be either. Say, 3–4 pages??

Let *N* be the NetTalk connectionist network discussed in class: it 'pronounces English text'. More precisely, *N* takes as input a letter *l*, and the surrounding letters, and produces as output a sound which is the pronunciation of that letter. That is, the pattern of activity on the input units 'represents' *l* and its context, and the output units 'represent' an English speech unit, a *phonological segment*. Recall that the output representation is distributed: each sound is encoded in the activity of a group of output units. Each output unit stands for one *phonological feature f*, and if *f* is present in the output segment, the *f*-unit is active (activation value = 1); otherwise the *f* -unit is inactive (activity = 0). The feature you are to discuss is *f* = *nasal*; all nasal consonants have this feature, and other consonants do not. English has three nasal consonants: *n*, *m*, and *ŋ*; the last, (named 'engma'), is the final consonant in the word *sing*.

Now imagine *N* is asked to pronounce the letter "n" in the word "sink". Suppose it performs correctly, and produces the output pattern for ŋ; the *nasal*-unit (call it *u*) will be active. Suppose the state of the network (the activation pattern over all input, output, and hidden units) is called *s*.

Suppose further that you are a cognitive scientist who proposes that *N* is a model of the neural circuitry in an English reader's brain, with each connectionist unit representing a single neuron. Call the reader *R* and call Σ the brain state of *R* when she is reading the letter "n" in "sink"

You are thinking at this moment about the state *s* of *N*. In fact, on your desk is a Dell computer *D* running a simulation of *N*, and on the screen are the numbers it has computed for the activation values of all the units in *N* for the input "n" in "sink". Call the state of this computer at this moment σ ('sigma'). The numeral on the screen that represents the activation of the unit *u* is 0.98. Call your brain state *B* as you look at this number while contemplating the screen.

The problem is to relate all the following things to each other; other similar such things may be included in your discussion too if that is helpful.

Some things

- the state *s* of the network *N*
- the symbol a_i in the activation equation for the network, where unit *i* is the *nasal*-unit *u*
- the activation level of *u*
- the activation level of the neuron ν ('nu') that *u* models
- the brain state Σ of reader *R*
- the numeral (symbol structure) "0.98" (which symbolizes a number)
- the number symbolized by "0.98"
- the symbol "9" in the numeral "0.98"

Some more things

- the phonetic symbol "ŋ"
- the sound symbolized by "ŋ"
- the phonetic feature f = *nasal*
- the open state of the velum (which physically produces nasality)
- the structure "[nasal, back, sonorant, consonantal]" describing the phonological features of the speech sound symbolized by "ŋ"
- the mental state M of R corresponding to the brain state Σ
- the part of the mental state M which corresponds to the sound sequence for "sink"
- the part of M which corresponds to the nasal sound in "sink"
- the aspect of the brain state Σ which corresponds to the nasal sound in "sink"
- the physical state σ of the Dell computer D simulating N
- the symbol "a[i]" in the program running on D
- the memory location μ in D where the value of the variable a[i] is stored
- the bit pattern π in the memory location μ encoding the number 0.98
- the third bit in the pattern π
- your brain state B
- your mental state C as you contemplate the screen (corresponding to the brain state B)
- the part of the mental state C which corresponds to the nasal sound in "sink" (if it exists -- does it?)
- the part of the mental state C which corresponds to the activation value of unit u (if it exists)
- the part of the mental state C which corresponds to the activation value of neuron ν (if it exists)
- the activation of a neuron β in B
- etc. …

The question is: **Just how are all these things related?**

You may find the following relations useful, although you are free to use whatever relations you like.
Some relations

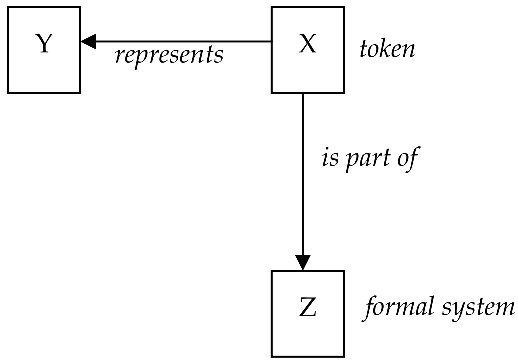
- X is a part of Y
- X represents Y
- X is an abstract description of Y
- X is the value of variable Y
- X is a state of Y

Which of the things listed above are (in Haugeland's terminology)

- tokens
- medium-independent
- digital
- formal systems
- endowed with original or derived intentionality

You are welcome to use additional concepts from the Haugeland reading to characterize the differences and relations between all the things.

You are invited to depict your answer in graphical form, as in:



A text accompanying such a diagram would be a good idea. You may find a diagram is not useful for certain kinds of information; a table or simply prose may be better.

You need not include in your discussion *all* the things listed above. This shouldn't take a huge amount of time, and don't do anything you think is busywork, a waste of time. Use your best judgment.