Prof. Dr. Gregor Schöner December 11, 2020

Exercise 6, due December 18, 2020 (again a Friday)

Like exercise 5, this exercise is somewhat aligned with material in Chapter 2 of "Dynamic Thinking: A primer on DFT" (available on the course web page under background reading). It is a good idea to read the rest of that chapter now.

Reminder (text identical with exercise 4):

The interactive web simulator "One Layer Field"[1] solves numerically the dynamic field with added random noise:

$$\tau \dot{u}(x,t) = -u(x,t) + h + s(x,t) + \int k(x-x')\, g(u(x',t))\, dx' + q\xi(x,t), \tag{1}$$

where the sigmoidal function is given by

$$g(u) = \frac{1}{1+\exp(-\beta u)}. \tag{2}$$

The interaction kernel is given by

$$k(x-x') = \frac{c_{\text{exc}}}{\sqrt{2\pi}\sigma_{\text{exc}}} \exp\left[-\frac{(x-x')^2}{2\sigma_{\text{exc}}^2}\right] \tag{3}$$

$$- \frac{c_{\text{inh}}}{\sqrt{2\pi}\sigma_{\text{inh}}} \exp\left[-\frac{(x-x')^2}{2\sigma_{\text{inh}}^2}\right] \tag{4}$$

$$- c_{\text{glob}}. \tag{5}$$

Note that in this formulation of the kernel, the amplitudes of the two Gaussian components are normalized, such that a change in the interaction widths σ does not change the total strength of the interaction. Localized input is supplied in the form

$$s(x,t) = \sum_i a_i \exp\left[-\frac{(x-p_i)^2}{2w_i^2}\right]. \tag{6}$$

Sliders at the bottom of the graphical user interface provided by the program enable one to control the widths, w_{si}, locations p_{si}, and amplitudes a_{si}, of three such inputs $(i = 1,2,3)$. Sliders are also available to vary the parameters $h, q, c_{\text{exc}}, c_{\text{inh}}$, and c_{glob}. Predefined sets of parameter values can be loaded by making a selection in the drop-down menu on the bottom right.

The state of the field is shown in the top set of axes. The blue line shows the current distribution of activation, $u(x,t)$. The green line is the input shifted by the resting level, $h + s(x,t)$, and the red line shows the field output (sigmoidal function of

[1] `https://dynamicfieldtheory.org/examples/one_layer_field.html`

the field activation) at each position, $g(u(x,t))$, scaled up by a factor of 10 for better visibility. In the bottom set of axes, the shape of the interaction kernel is displayed. Note that the kernel is plotted over distances in the feature dimension, with zero at the center of the plot. This interaction pattern is then applied homogenously for all positions in the field.
End of reminder from exercise 4.

The following tasks work best with the predefined parameter set "memory". Each task first requires an exploration of the field dynamics using the simulator. The main task is, however, to describe what you did, what the outcome was, and *how you interpret it*. Write a coherent text that is supported by ample illustrations.

1. First, familiarize yourself with the notion of sustained activation: Induce peaks at the three default locations of localized input (with the "amplitude Si" slider where i is 1, 2, 3). In each case, return the amplitude slider to zero once a peak has formed. Now lower the resting level in small steps. At some point the peaks decay. Keep that resting level and induce peaks again. What happens and why?

   Restart by resetting the resting level to its original value (or reloading the webpage) and selecting the "memory" parameter set. Set up the same sustained peaks as before. Now lower the level of excitatory interaction. Briefly describe what you observe. Together with the first simulation, interpret this finding relative to the memory instability.

2. Restart with the "memory" parameter set. Induce a peak, remove localized input, then reintroduce this input in a location close to the sustained peak. What happens? Restart and do the same, but now with the second localized input at a location far from the sustained peak. What happens? What would be a possible interpretation of this behavior of the model in terms of human working memory for metric information?

3. Restart with the "memory" parameter set. Induce a sustained peak at the center and remove localized input to zero. Next, induce another peak on the left, but do not remove its localized input all the way to zero. Instead, hold it at a strength of around 2, for instance. Observe the position of both peaks. Interpret your observation relative to the discussion of drift in the lecture and book chapter. What other psychophysical experiment could uncover such an effect?

4. Restart with the "memory" parameter set. Induce a peak on the right, for example, and remove localized input. Now make the width of the center input very broad and slowly shift its amplitude up, but only to very low values. Describe what happens. Interpret this observation relative to the issue of drift in metric working memory. What is different from the effect observed in the previous task?