NeckSoc.exe technotes

- *The code and technotes for NeckSOC.exe were written by J.C. Sprott in collaboration with D. J. Aks. The program tests the SOC model of human perceptual behavior reported in their (2003) study: Aks, D.J. & Sprott, J. C. (2003) **Resolving perceptual ambiguity in the Necker Cube: A dynamical systems approach**. Journal of Non-linear Dynamics in Psychology & the Life Sciences, 7(2) 159-178.*

<--- Notice how the orientation of the **Necker Cube** appears to flip spontaneously over time.

NeckSoc.exe is a powerBASIC simulation of the perceived flipping of the Necker Cube. Per Bak's model of Self-Organized Criticality (SOC; Bak, Tang & Wiesenfeld, 1988) is applied to a neural network to simulate shifts in the percept. SOC drives the cell interactions and subsequent spreading of activity in the network. Shifts in the cube's orientation are the global effect of local neuronal interactions.

NeckSOC.exe illustrates how perceptual flips can be the consequence of simple **SOC rules**:

-

7/1/05

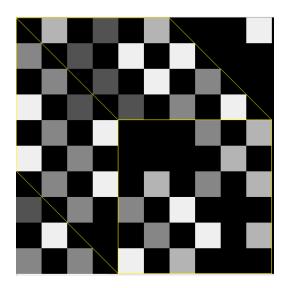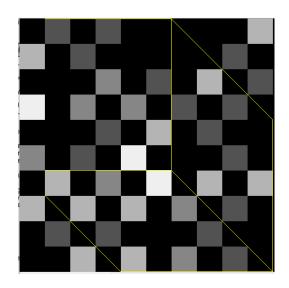|	• **SOC rules**
Z (x,y) = activation level for a given cell in the network. $0 < x < 4$ $0 < y < 4$ Zcr= 3	• For $Z(x,y) > Zcr$ • $Z(x,y) \rightarrow Z(x,y) - 4$ • $Z(x \pm 1,y) \rightarrow Z(x \pm 1,y) + 1$ • $Z(x,y \pm 1) \rightarrow Z(x,y \pm 1) + 1$

Using NECKSOC.exe:
{NeckSoc.exe OS requirements: Windows or DOS)

When starting NECKSOC.exe you will be prompted for 10 parameters (e.g., matrix size, # grains dropped, weight...). These parameters are described below. To use default values, press 'enter' after each prompt; otherwise, type in your preferred values.

After the initial entry of these parameters, you will see (yellow) edges of the Necker Cube superimposed on a matrix of white, gray and black cells.

NeckSoc.exe technotes

Each cell represent neurons, or clusters of neurons, with similar receptive fields[1]. The shading indicates the level of activation of each cell (range = 4 units). White indicates the highest level of activity (ng=3) and black indicates the lowest level of activity (ng=0). Activity aggregated across individual cells determines which cube (outlined in yellow edges) is most active.

The initial distribution of activity across the network is random. One site is randomly stimulated by incrementing the activation by 1 unit. Spreading activation occurs when the simple SOC rule is applied: when the activity in a single cell exceeds a critical value of 3; For $Z(x,y) > Zcr$; $Zcr=3$; then activity from the site is depleted to 0; $Z(x,y) \rightarrow Z(x,y) - 4$, and is evenly 'distributed' to four adjacent regions; $Z(x \pm 1,y) \rightarrow Z(x \pm 1,y) + 1$, and $Z(x,y \pm 1) \rightarrow Z(x,y \pm 1) + 1$. The simple sequence is repeated many times, and the result is a complex spread of activity across the network and the intermittent flip of the cube.

- **Data Output** NeckSoc.exe outputs the time steps *{define}* between flips to a NeckSoc.dat file. Thus, the data series consists the sequence of 'flip times.'

- **Parameters** (default value).
  Note that some labels refer to Bak s original sand pile model where grains of sand are avalanching to the ground as a result of iterating the SOC rule. In our model of per-ceptual flipping, the grains correspond to neural activity and the avalanche refers to the spread of activity.

  Size of matrix (n=10) is the side dimension of the square matrix. When n=10 the matrix contains 100 cells.

  Number of grains dropped (ng=1) refers to the increment in activation level. (the term grains is borrowed from Bak's original sand pile model but here you can think of

---

[1] Receptive fields refer to the region of the retina & the type of information that a neuron tends to respond to. Here, oriented lines making up the Necker Cube will trigger activity in certain V1 type of neurons

NeckSoc.exe technotes

these as neuronal activity). The shading on each cell indicates the level of activation which can range from 0 to 3 units. The network begins w/ a random activation levels. In human vision, activation of neurons can result from environmental stimulation or through changes in attention.

Avalanche threshold (c=4) is the critical threshold of a cell which when reached drops to 0 and surrounding cells are incremented by 1 unit. This represents spread of activation across neurons.

Maximum number of data points (max=32000) is the limit to the resulting data series. Notice that the data series consists of the time steps between flips.

Hysteresis (h=0) is a lag parameter to postpone flipping until a cumulative 'flip' threshold of activation is reached across clusters of cells.

Minimum time between flips (thresh=0) permits user to restrict the minimum time (i.e., steps) before the necker cube flips.

Weight bias (b=0) permits user to specify an initial 'weight' and thus greater activation for a particular cube.

Preferred propagation direction (R/L/N)" (P=N; neutral) permits user to specify the direction of the spread.

Dissipation rate (a=0) permits user to specify the rate at which a stimulated cell loses its activity to surrounding cells (?)

Graphics (Y/N/C; default = Y) permits user to view graphic representation of SOC model. SOCNeck.exe works much faster *(specify)* with graphics turned off (Graphics=N). *(C?)*

Future plans for NeckSOC:

•Platform independent version in alternative code (i.e., C+).

•Interface with Matlab for automated data anslysis on time series output.

•Addition of inhibitory parameter in the next version of NeckSoc.exe).

References

* *Aks, D.J. & Sprott, J. C. (2003)* **Resolving perceptual ambiguity in the Necker Cube: A dynamical systems approach**. *Journal of Non-linear Dynamics in Psychology & the Life Sciences, 7(2) 159-178.*

* Bak,P., Tang,C. & Wiesenfeld, K. (1988). Self-organized criticality, Physical Review A 38, 364-374.