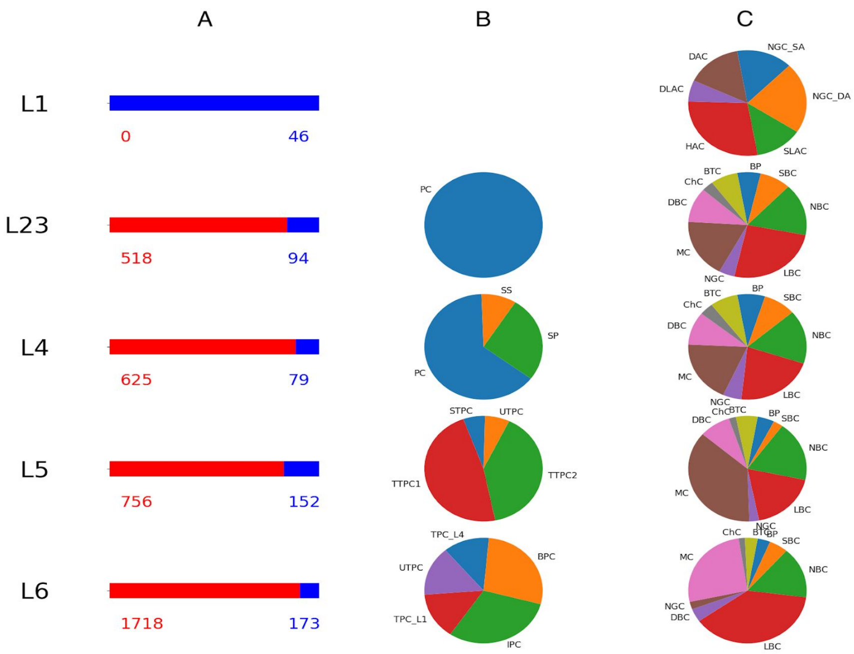
Based on the data available at [nmc-portal](), a Python algorithm was developed [(github)]() that, taking into account the layered distribution of neurons and the connection, connected neurons of various morphoelectric types through synapses and reproduced neocortical columns of various scales.Also, Python code was developed that allowed adjusting the number of neurons in a column according to the required scale. 2 separate columns were modeled, adjusting the number of neurons in the column so that approximately 5% and 15% of the biological data were presented in the reconstruction. The total number of neurons in the 5% and 15% column was 1442 and 4161, respectively. The result of our distribution is shown in Fig. 1.1.



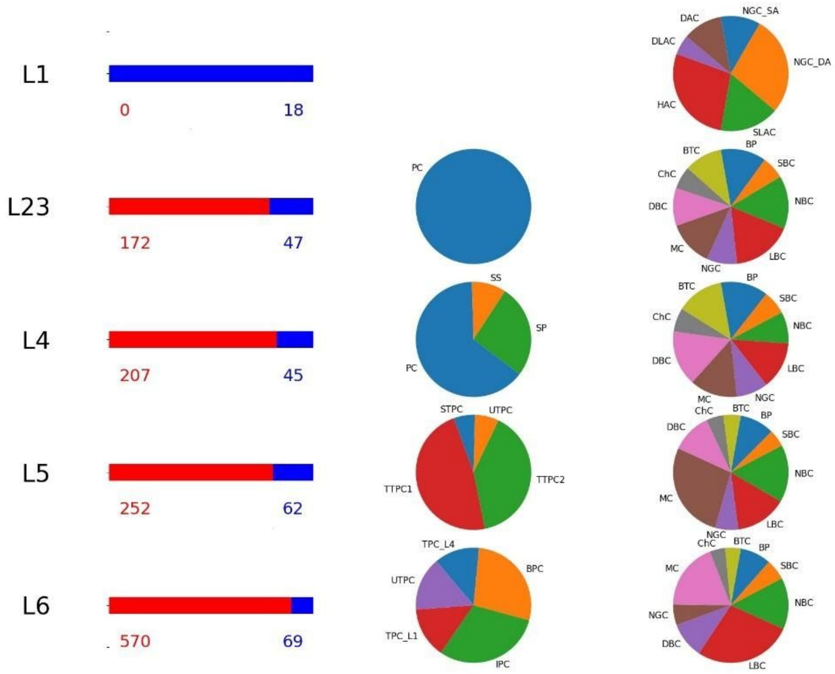


Figure 1.1 - a layered display of the distribution of neurons in reconstruction. Top for a 15% column, bottom for a 5% column. (A) Percentage of excitatory (red) and inhibitory (blue) neurons. (B) Layered distribution of inhibitory neurons of various m-types. (C) Layered distribution of exciting neurons of various m-types

It is worth noting that the main problem was not only to reduce the dimension, but also to maintain the corresponding structure of interneuronal connections that was presented in the biological column, connecting neurons through synapses, in accordance with their distribution and connection (Fig. 1.2).

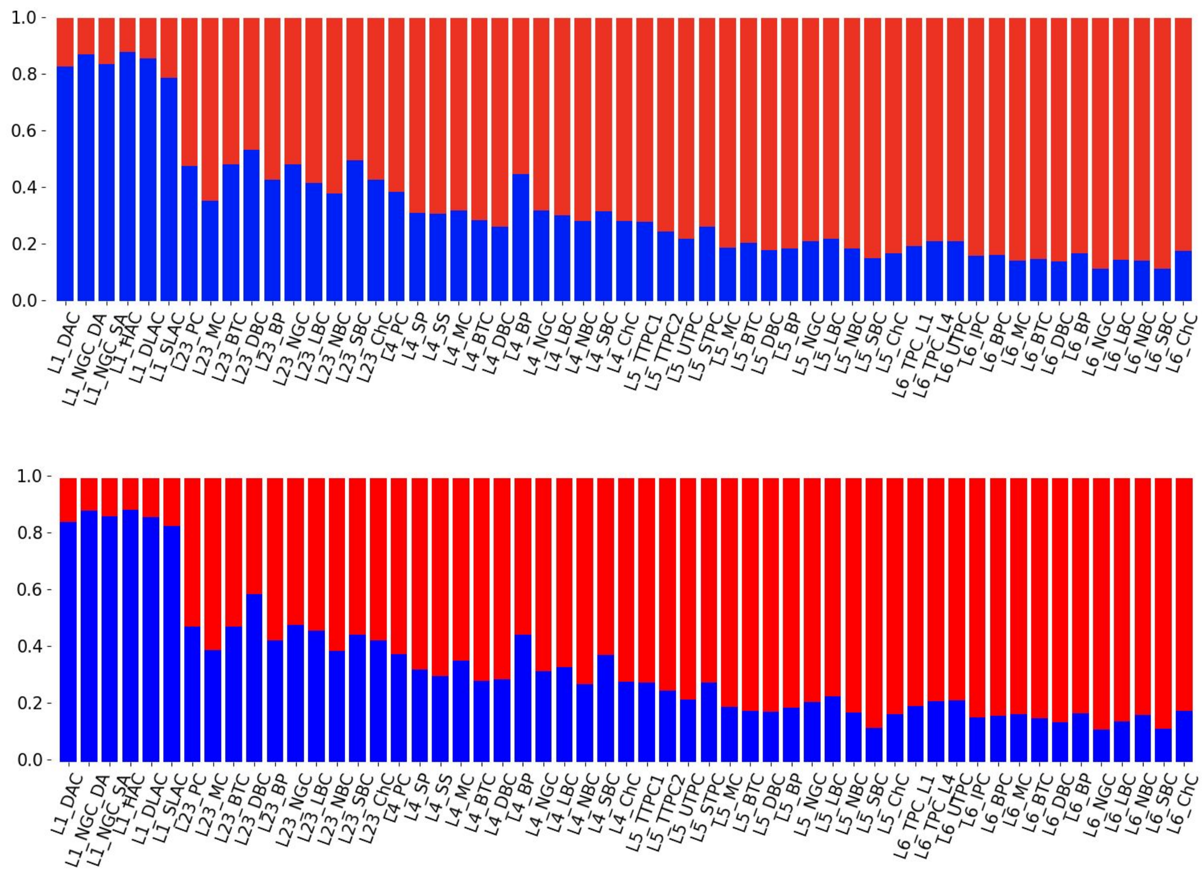


Figure 1.2 - the average ratio of excitatory and inhibitory synapses per m-type. The top is a simulated 15% column, the bottom is a simulated 5% column

2 simulations were carried out for two different scales over 3000ms. For 4161 neurons, the time spent on calculation was 33 hours 26 minutes, and for 1442 it was 10 hours 17 minutes. To conduct the simulation, a program code was created in Python, which allowed parallelizing the simulation process in the GoogleCloud cloud (12 vCPU and 78GB of RAM) using the OpenMPI library. The simulation result was a record of the membrane potential of each neuron. In fig. 1.3 shows the result of the simulation, namely, the moments of occurrence of the action potential in neurons. It should be noted that in this simulation, a threshold of tonic depolarization of 100% and Ca2 + = 2.0 mmol is used

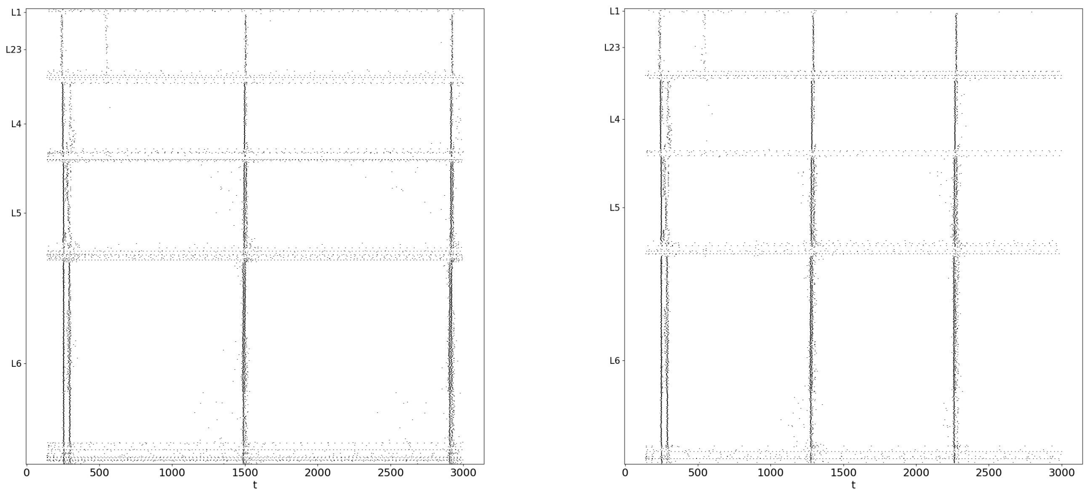


Figure 1.3 is the result of simulation of all simulated neurons. On the left - a raster diagram for 15%, on the right - for 5%.

Under such conditions, synchronous column activity is observed with a frequency of 1-1.5Hz

It depicts in more detail what happens during synchronous activity for the 15% and 5% columns in Fig. 1.4, 1.5, 1.6, 1.7. At the first synchronous activity, the behavior pattern of neurons (L5-> L6-> L4-> L23-> L6) does not repeat, but at the second and third synchronous activity it acquires similar outlines. This is especially evident in Fig. 1.6, 1.7, which shows the relative number of excited neurons per layer, with synchronous activity.

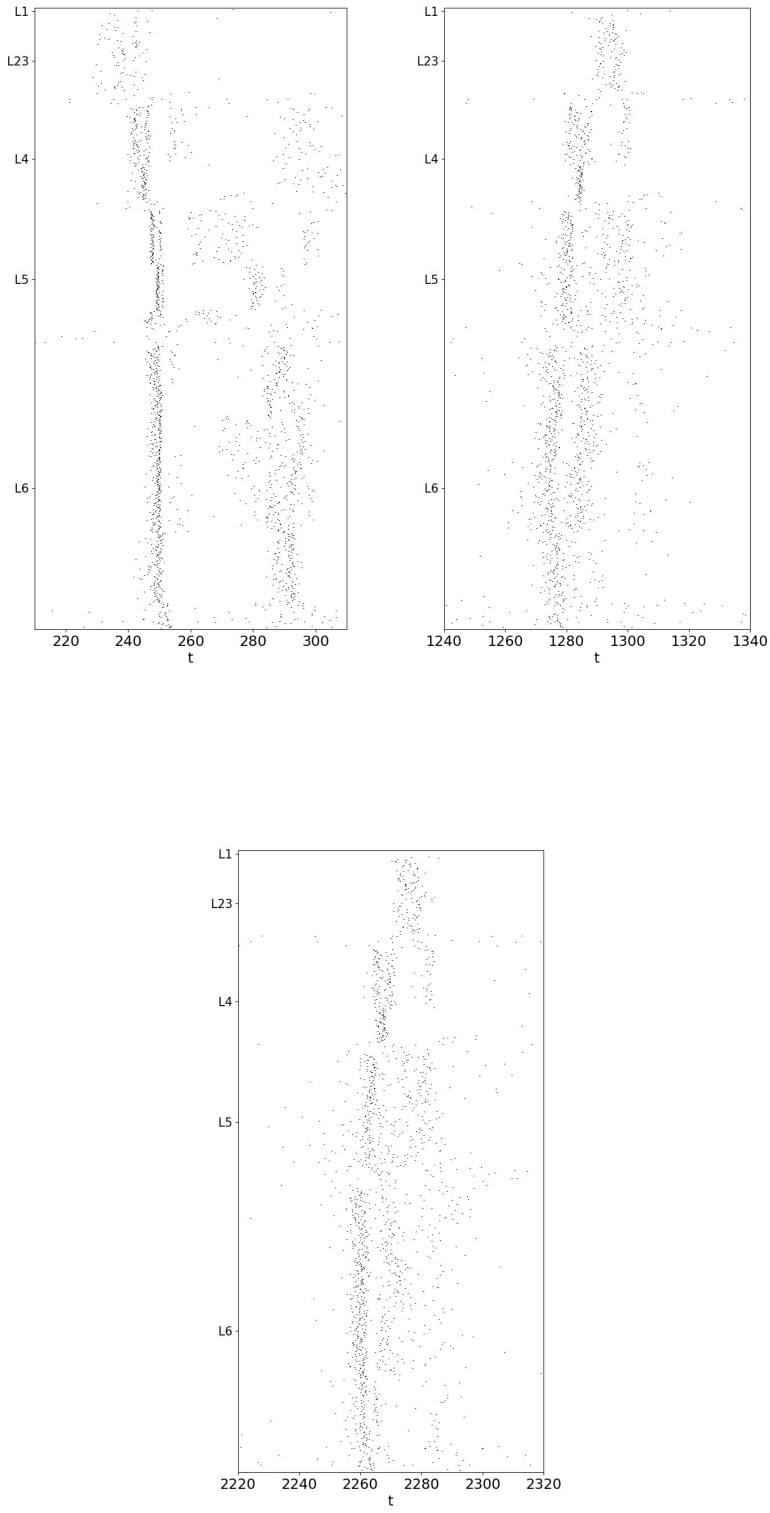


Figure 1.4 - raster diagram of neurons for 15% of the column - during the first, second and third synchronous activity.

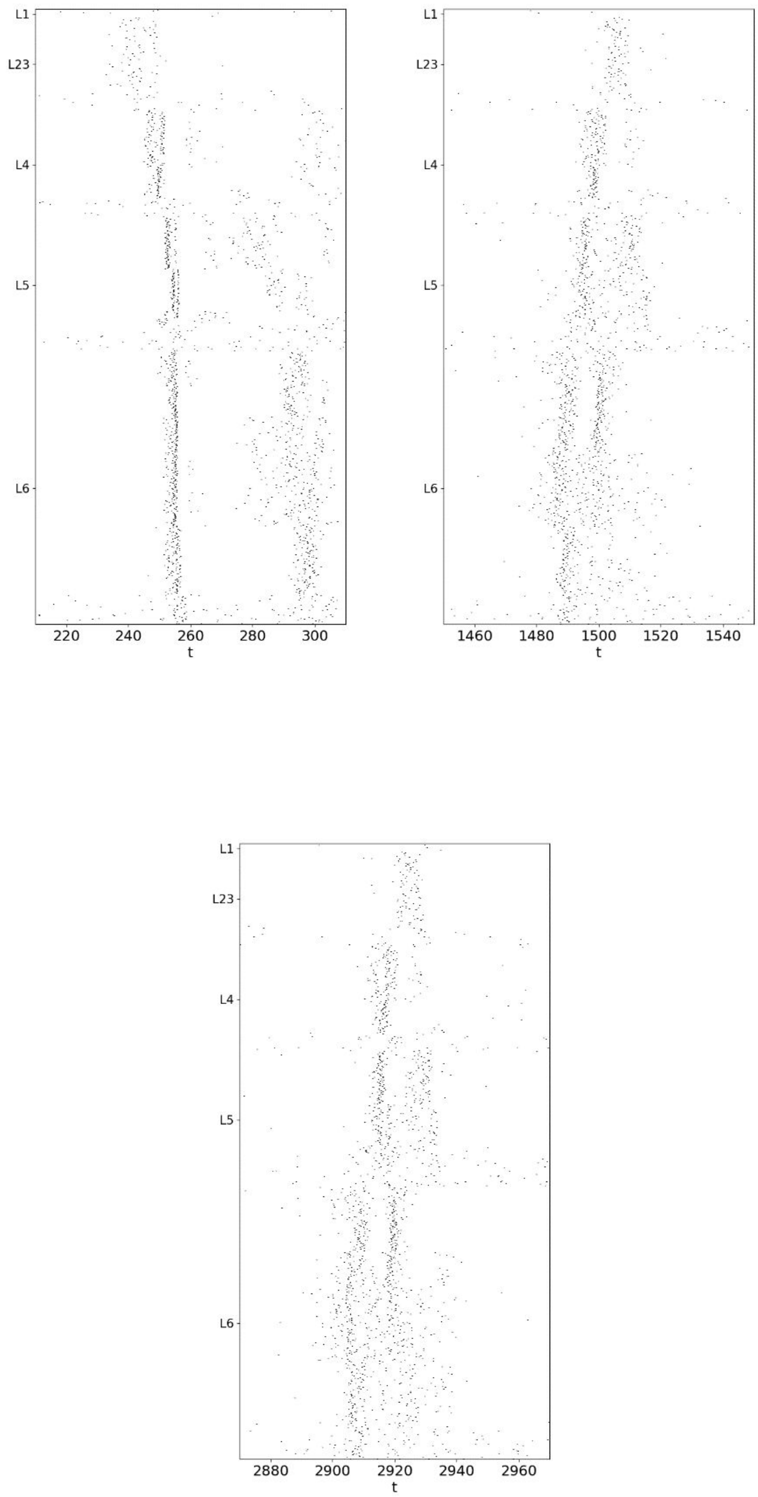
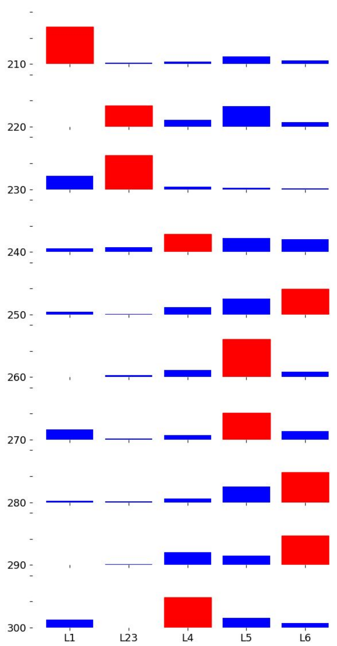
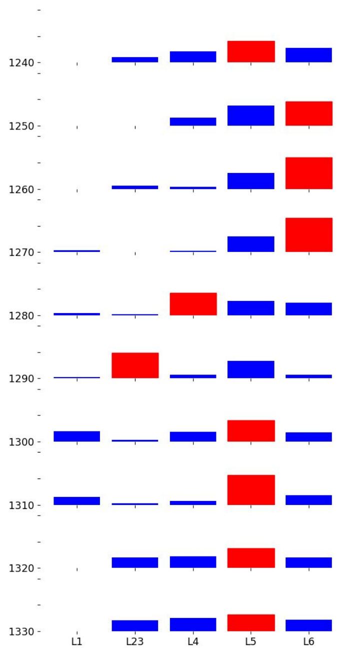


Figure 1.5 - raster diagram of neurons for 5% of the column - during the first, second and third synchronous activity.


210
220
230
240
250
260
270
280
290
300
L1
L23
L4
L5
L6


1240
1250
1260
1270
1280
1290
1300
1310
1320
1330
L1
L23
L4
L5
L6

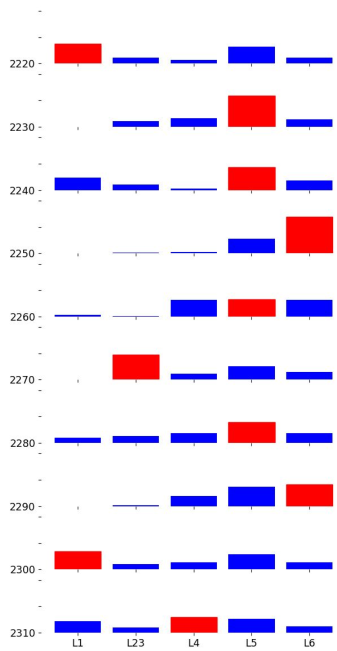

2220
2230
2240
2250
2260
2270
2280
2290
2300
2310
L1
L23
L4
L5
L6

Figure 1.6 is a histogram showing the development of the pattern of neuronal activity for 15% of the column for each layer during the first, second and third synchronous activity. Red shows the largest relative number of excitatory neurons in the layer.

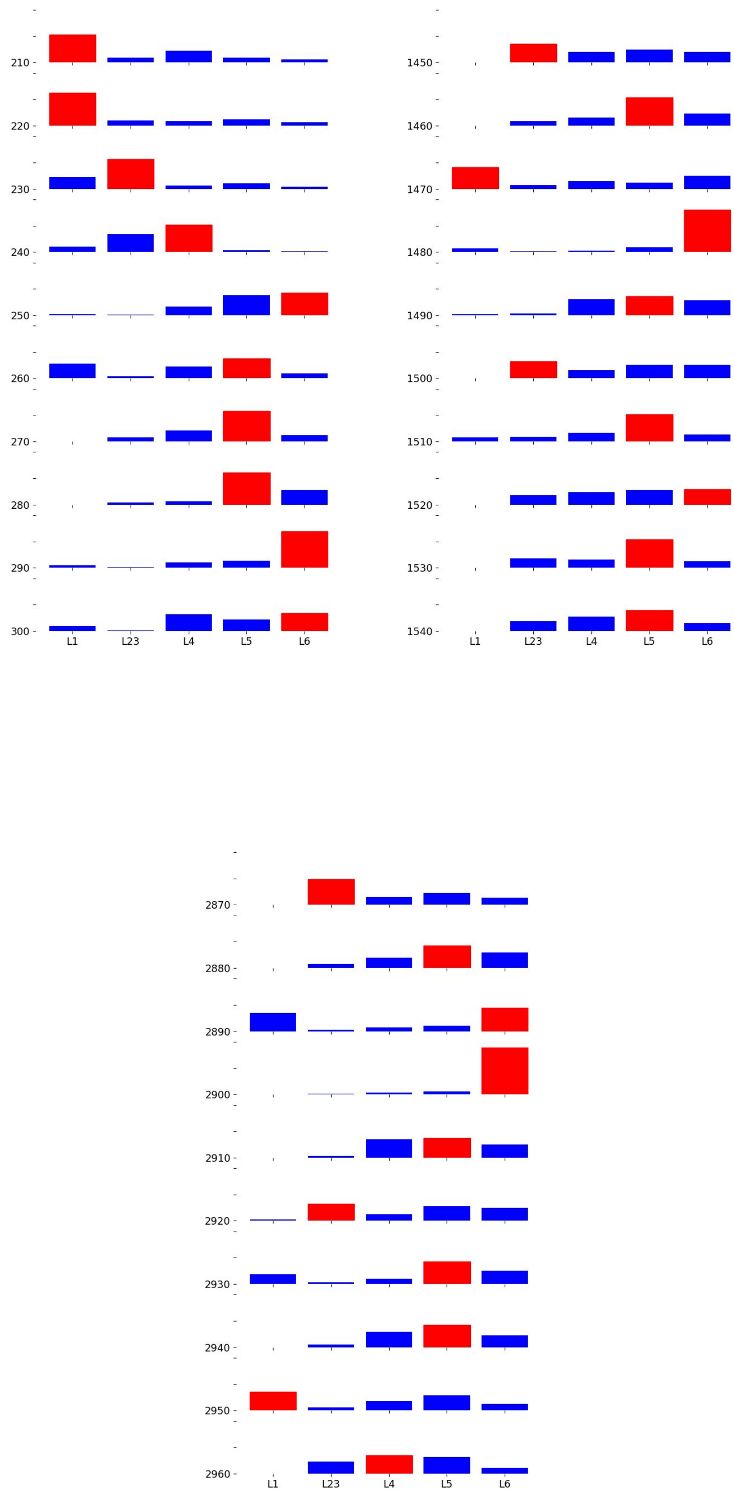


Figure 1.7 is a histogram showing the development of the pattern of neuronal activity for 5% of the column for each layer during the first, second

and third synchronous activity. Red shows the largest relative number of excitatory neurons in the layer.

If we compare the simulation results for columns of different scales, it is clearly seen that the frequency of synchronous activity in a 15% column is more stable and is ~ 1 Hz, but for a 5% column it is not stable and is (~ 1.2-1.4 Hz).

CONCLUSION

In this paper, we studied the idea of reducing the dimension of reconstruction of a neocortical column using computer simulation. When comparing the results of a reduced reconstruction for the first time with the results of the Blue Brain team, it can be argued that the idea has the right to life, but requires a more detailed study and comparison of experiments.

Neocortical reconstruction, during synchronous activity, showed similar results compared to "Reconstruction and Simulation of Neocortical Microcircuitry 2015", namely the frequency of synchronous activity, for a column with 1422 neurons the frequency was higher. At the same time, a more detailed examination of the behavior of neurons, the pattern observed by the Blue Brain team, could only be detected during the second and third phases of activity. But it is worth noting that for the reconstruction, the Blue Brain team used 7 neocortical columns containing approximately 139834 neurons, and the reduced reconstructions - 4161 and 1422 neurons.

If, on a reduced scale, the results that were observed on a larger scale are reproduced, then this will provide the basis for a further search for answers to questions - why so? Why does a column make up such a number of neurons in the brain? If it is possible to work/explore a reduced model, then what are the boundaries in this reduced model?

I recommend using the results of the study as a fundamental idea for conducting more comparative experiments between reconstructions of various scales (in silico) and biological (in vitro, in vivo) studies.