An Exploration of Feasibility of Computing the Connectome Reveals Fundamental Features of Brain Development

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As higher brain functions emerge from the activities of connected neurons, an available map of all neural connections would greatly facilitate the understanding of brain functions. Large scale experimental projects already aim to establish a high resolution description of the Connectome, but perhaps an alternative, computational approach can achieve the same goal. What data would be needed, what algorithms should be applied? Simple calculations tell that the coding requirement for the complete connectome is at least 6 orders of magnitudes larger than the entire intrinsic coding capacity of the single cell from which the functional brain ultimately emerges. We can draw the immediate conclusion, that the main sources of brain complexity are not intrinsic. Calculating similar coding requirement vs. coding capacity ratios for model animals reveals the limits of usefulness of the model animals in studying human conditions.

We estimate, that in 4 minutes more data flows into the brain from external sources than all the data stored in the chromosomes. The amount of input reaching the brain during the critical first two years of development is 40 thousand times the amount of data in the genome. It is mostly this input that imprints functional circuits, and it does the job through self-organization.

Living organisms exhibit input driven self organization (forming bones trabecular structures, acquiring immunity to pathogens), that is analogous to artificial neural nets unsupervised learning. Even for basic brain functions (seeing, hearing), input is essential and dominant, absence or inappropriateness of input leads to disorder (amblyopia, autism). Designer functions are formed de novo by controlled neural stimuli (color vision in mice, electronic prosthetics for restoring vision). Major evolutionary development (emergence of language) can be hypothesized by past shifts in visual inputs.

External signals are dynamic, individual, and non-recurring, yet, emergence of basic brain functions is universal. This suggests that the developmental process is robust, and modeling of neural networks is feasible. But instead of parsing downstream intermediates, analyzing the primary driving forces (the input) directly would be the more promising approach to unraveling the underlying causes of mental conditions.