

Drawing parallels between solving the nervous system and linear algebra

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The deep principles underlying many discoveries in physics bear a strong resemblance to the methods used in linear algebra – specifically, in solving large systems of linear equations that have a unique solution. In such systems, the relationships between variables in each equation offer crucial clues that guide us toward the final answer. To solve for all variables, the system must contain at least as many independent equations as there are unknowns. Similarly, the nervous system presents us with a vast array of findings across many different levels – molecular, cellular, systems, behavioral, and experiential. By identifying and using even subtle interconnections among these observations, we can begin to piece together the full picture. This is an enormous challenge, especially since biology lacks the neat, standardized methods that exist in mathematics. However, understanding the logic behind linear algebraic solutions can provide a useful conceptual framework.

Take, for example, the Gauss-Jordan elimination method in linear algebra – a tool designed to systematically solve a system of linear equations. It was developed by someone who not only grasped the deeper principles behind such systems but also worked to simplify the process for others. Although linear algebra problems can also be solved by trial-and-error, such methods become inefficient as the number of variables increases. Availability of Gauss-Jordan method even makes us to forget that a system of linear equations can be solved by trial-and-error method. By viewing nervous system as a large system of equations (both linear and non-linear) and there is no short-cut method like Gauss-Jordan to solve it, it needs to be solved by trial-and-error method. When dealing with a complex system containing many distinct observations (akin to equations), the true solution will be the one that ties all of them together. One practical approach is to work with subsets of findings – looking for solutions that can explain a few observations at a time. In linear algebra, different subsets of equations will likely give many solutions – and from these, a common solution for all the

variables may be found. A similar approach can be undertaken for the nervous system. Alternatively, sets of findings having all the variables in them can be used to find a unique solution.

Encouragingly, the complexity of the nervous system doesn't mean endless ambiguity. On the contrary, if there is only one unique solution, incorrect ones can often be ruled out quickly. Importantly, some components of this mechanism may remain imperceptible to our sensory systems, even after they are identified. However, we expect these components to show testable changes during learning, which are reactivated during memory retrieval, triggering the basic units of internal sensation. The integration of these units is expected to result in the qualia of memory – the subjective experience associated with remembering.