Phillips & Silverstein – Convergence of biological and psychological perspectives on cognitive coordination in schizophrenia

<CT>Where the rubber meets the road: The importance of implementation

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<C-AB>Abstract: Phillips and Silverstein argue that a range of cognitive disturbances in schizophrenia result from a deficit in cognitive coordination attributable to NMDA receptor dysfunction. We suggest that the viability of this hypothesis would be further supported by explicit implementation in a computational framework that can produce quantitative estimates of the behavior of both healthy individuals and individuals with schizophrenia.

<C-text begins>**Phillips and Silverstein** put forth an interesting and provocative hypothesis as to the ways in which NMDA receptor dysfunction might lead to disturbances in cognitive coordination in schizophrenia. They do an elegant job of synthesizing psychological, computational, and neurobiological perspectives on the cognitive coordination construct and its underlying mechanisms. We are grateful that **Phillips and Silverstein** acknowledge our own work (with Jonathan Cohen and colleagues) as trying to achieve similar goals with regard to understanding cognition in schizophrenia (Braver et al. 1999). **Phillips and Silverstein** contrast their hypotheses to our theory, which suggests that one of the core cognitive deficits in schizophrenia is a dysfunction in the ability to represent and maintain context information, as a result of a disturbance in dopamine function in prefrontal cortex. **Phillips and Silverstein** highlight a potentially more fundamental mechanism of context processing (cognitive coordination in their model) that involves the NMDA-receptor and computational processing within cortical modules as well as between cortical modules. As such, **Phillips and Silverstein** suggest that deficits in the kinds of cognitive control mechanisms that are central to our theory could arise from disturbances in basic mechanisms that may be involved in processing throughout the entire brain. This contrasts with our theory, with focuses on processing mechanisms that more selectively involve dopamine interactions with prefrontal cortex, and the cognitive capabilities that depend on such interactions. We have argued that disturbances in such mechanisms among individuals with schizophrenia give rise to relatively selective cognitive deficits that are most severe under particular task conditions.

We are excited by the prospect of a theory of cognition in schizophrenia that attempts the same integration of psychological, computational, and neurobiological perspectives that we have tried to incorporate in our work. An especially exciting prospect is the suggestion by **Phillips and Silverstein** that their mechanism could account for deficits among individuals with schizophrenia both on high-level cognitive tasks as well as in more basic sensory and perceptual domains. If this were true, it would constitute an advance on our own theory, which is admittedly more constrained in terms of the phenomena for which it attempts to account. Phillips and colleagues have conducted computational studies demonstrating that NMDA-receptors have properties (i.e., their voltage-dependence) that allow them to help organize processing and learning. However, a more convincing demonstration of the explanatory power of the **Phillips & Silverstein** model would be to explicitly demonstrate that a disturbance in the same mechanism could lead to changes in both high-level cognitive processing and sensory/perceptual (e.g., Gestalt grouping phenomena). **Phillips and Silverstein** refer to a distinction between computational theory and computational modeling. Their theory seems to be rooted in the former approach. In contrast, our work has focused on the latter approach, using simulations of specific cognitive tasks. We would advocate that explicit simulations of cognitive tasks provide a useful means by which to compare and contrast theories such ours and that of **Phillips and Silverstein.** In particular, simulations of actual cognitive tasks enable quantitative estimates of the success with which a model can account for the relevant behavioral phenomena. Such estimates provide an objective metric by which to evaluate competing models. For example, one would judge the **Phillips & Silverstein** model to be a more successful model of cognition in schizophrenia than our own if, in addition to accounting for sensory/perceptual phenomena, the **Phillips & Silverstein** model could also account for the behavior of individuals with schizophrenia on tasks such as our AX version of the Continuous Performance Test (a task that our theory suggests is highly dependent on integrity of context processing functions) with the same degree of success that our model can. Such explicit implementation may also help to identify task conditions that would help arbitrate between competing theories. For example, our simulation work has suggested that deficits in context processing among individuals with schizophrenia should be amplified under conditions in which context needs to be actively maintained in working memory and/or used to inhibit dominant response tendencies that are not appropriate for the task at hand. A number of empirical studies provide support for these model predictions (e.g., Barch et al. in press; Cohen et al. 1999; Javitt et al. 2000; Servan-Schreiber et al. 1996; Strata et al. 1998). However, it is not clear from the level of description provided by **Phillips and Silverstein** whether their theory would also predict that such factors should influence the severity of cognitive deficits in schizophrenia. It is also possible that simulations of specific cognitive tasks in the **Phillips & Silverstein** framework would identify other conditions that are especially dependent on their proposed NMDA-receptor mechanism. In our experience we have found that the process of simulating empirical phenomena forced us to refine and elaborate our initial conceptual hypotheses in ways that we could not have predicted ahead of time. In summary, we are intrigued by the theory put forth by **Phillips and Silverstein** and encourage the authors to take this theory to the next level by providing an explicit computational implementation that can be compared with competing theories.<c-text ends>

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