The early development of arithmetic skill is an important, enduring, and widely studied topic. It is known that children's arithmetic strategies transition from overt, effortful, unreliable skills such as finger counting, to more efficient, reliable, and often covert skills, such as highly proceduralized covert strategies, and sometimes direct memory retrieval. In the '80s and '90s specific theories, often instantiated in computational models, were proposed to explain these transitions. Recently, however, shas produced detailed descriptions of how multiple cognitive systems (memory, language, control, visual, motor, etc.) interact via distributed brain networks (etc.) in complex cognition, and how theseinteractions development. Earlier models of arithmetic development have not been updated to encompass these results. The present proposal aims, first (1) to update previous theories and computational models of early arithmetic development to create a new neurocomputational framework that encompasses findings from systems neuroscience; and second (2) to apply the new framework to provide hypotheses regarding observed comorbidities relating atypical language and arithmetic development.

Specific Aims

Aim 1: Revise existing computational models of children’s arithmetic strategy use and change to encompass our recent understanding of how the brain *typically* works and develops as a cognitive system.

*Hypothesis 1A*: The revised models can reproduce observed regularities in strategy usage and change, as could the old models. (I.e., They are no worse than the existing models in encompassing the basic performance data.)

*Hypothesis 1B:*  The revised models furthermore reproduce and provide explanations for observed regularities in the interactive activation patterns among neuro-pathways in brain systems during performance. (I.e., They can additionally encompass systems data.)

*Hypothesis 1C:* The revised models furthermore reproduce and provide explanations for observed *changes* in interactive activation patterns across development. (I.e., They can additionally encompass systems-level developmental data.)

An example of the sort of explanation that could be developed from this aim is that the development of cognitive control supports transition to memory retrieval of arithmetic facts and the dynamic change from counting to retrieving in turns stabilizes the maturation of the cognitive control system.

Aim 2: Explore *atypical* comorbidities in language and arithmetic development by studying atypical parameterization of the model, and/or revising it as needed to encompass these regularities.

*Hypothesis 2A*: Manipulations of model parameters such as learning rate, decay rates (analogous to synaptic plasticity), and so on may enable the existing (revised) model to reproduce atypical patterns of arithmetic skill development, especially as regards language comorbidity.

*Hypothesis 2B*: We expect the 2A will be refuted, and that reproducing the desired patterns will require structural changes to the models, but that with such changes we will be able to accomplish the goal, and that these changes will be related to changes hypothesized (and/or observed) in the systems neuroscientific study of atypical development.

An example of where models revised in this aim may provide useful explanations is in predicting that language can support arithmetic learning by providing unique symbolic representations for numbers, but that noisy representations can hamper successful learning.