Simulating Individual Differences in Reading Acquisition using Convolutional Neural Networks

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Specific Aims

1. Develop a normative model of reading using deep learning for orthographic input.
2. Explore the capability of such a model to capture individual differences in reading.

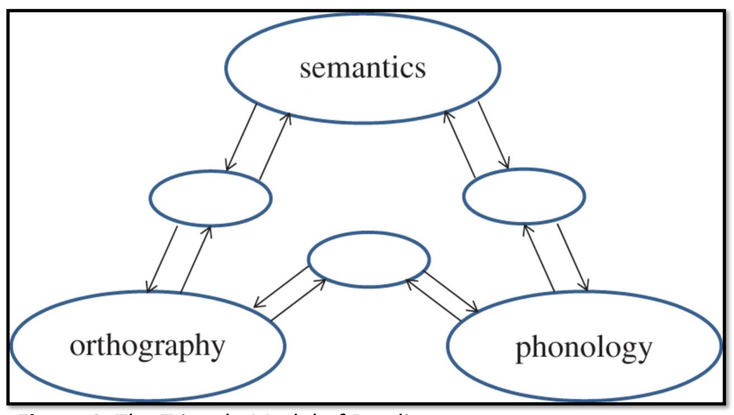


Figure 1. The Triangle Model of Reading

Theoretical Framework

Developmental dyslexia and treatment resistance. While treatment can improve outcomes, about 20% of children fail to improve with treatment proven effective for other children (see Al Otaiba & Fuchs, 2002).

Computational models of reading development. The Triangle Model (Figure 1) is a connectionist model that has been used to investigate differences between typical and dyslexic reading (Harm & Seidenberg, 1999). Differences in the control parameters can be seen as analogues to differences in neurobiological factors between readers (Pugh et al., 2014).

Generating orthographic representations using deep learning. Convolutional neural networks (convnets, Figure 2) were inspired by the visual cortex. They are characterized by local connectivity and are widely used for image recognition (LeCun et al., 1998).

Methodology

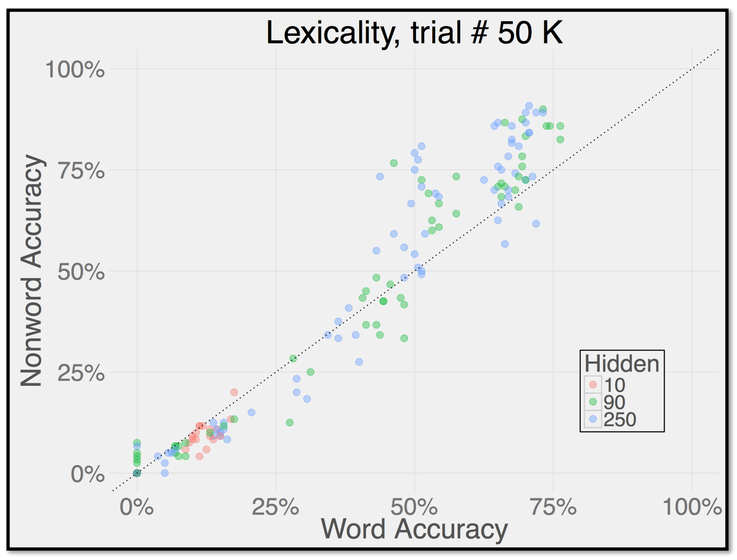
This project will be completed in two phases:

1. Implementation of a convolutional version of the Triangle Model of reading.
2. Running multiple simulations to examine the ways hyperparameters affect model performance, specifically with regards to developmental dyslexia.

Preliminary Results

Modeling Reading. Multiple simulations have been run that allow parametrically manipulated control parameters to determine the structure of the network and the noise in the phonological attractor (Figure 3).

Deep Learning. Early versions of the model using a convnet to learn the orthographic representations have been able to correctly identify letters in sequence.



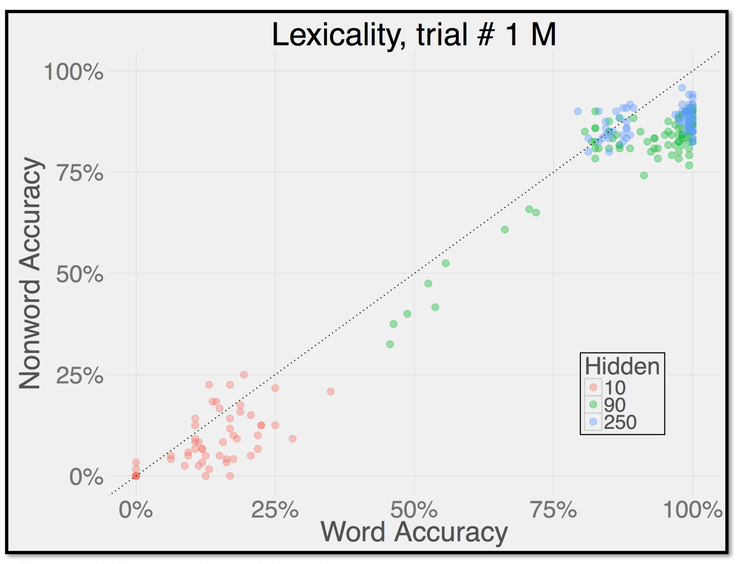


Figure 2. Parent Grant Modeling

Future Directions

Modeling dyslexic reading across languages. This project will be a significant step toward modeling dyslexia in languages with very different orthographies (e.g. English and Chinese). They may help explain why dyslexia can differ by language.

Modeling bilingual reading. This model could also learn to read multiple languages concurrently, resulting in bilingual networks. It may also advance models of reading in languages that make use of more than one orthography (e.g. Japanese).

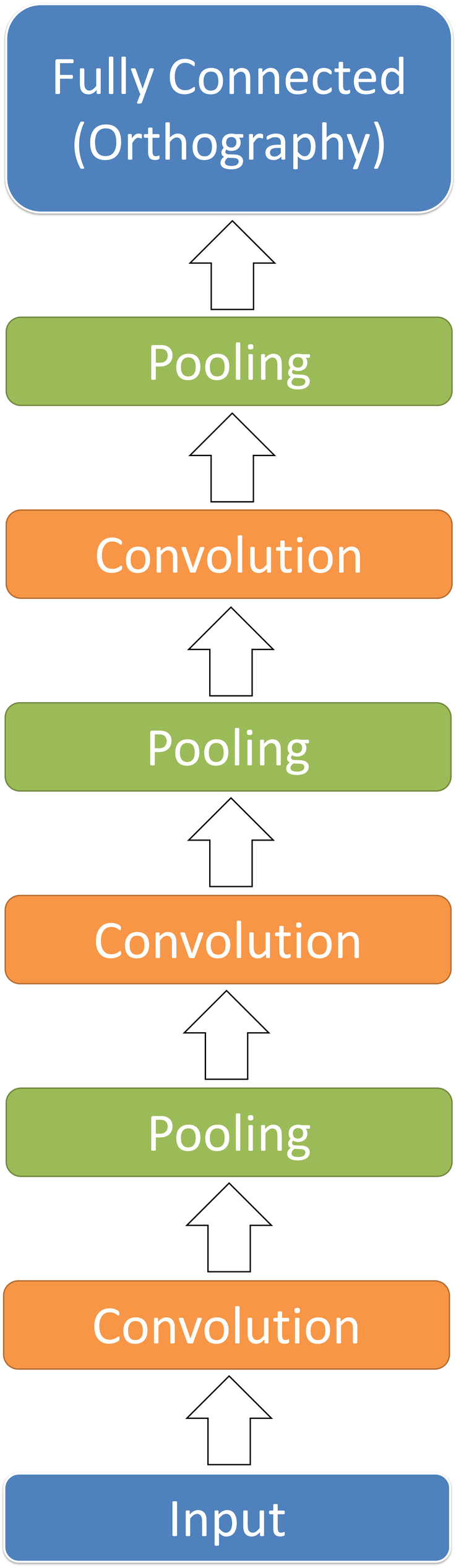


Figure 3. Network Structure (based on LeNet-5)

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References

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