Incorporating Semantics in a Connectionist Model of Reading Aloud: Surface Dyslexic Behavior with a Single Mechanism

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This study investigates the mechanism by which English words are read aloud. Building on the previous work of Plaut, McClelland, Seidenberg, & Patterson (1996), a semantic representational layer is incorporated into a connectionist model that maps orthographic inputs to phonological outputs. When lesioned, this network exhibits behavior characteristic of surface dyslexics.

Background

In English, the spelling-sound mappings for many but not all words can be described by regular rules. For example, while MINT, TINT, PRINT, and STINT all rhyme, PINT is pronounced differently. The dual mechanism view of word reading (Coltheart, Curtis, Atkins, & Haller, 1993; Pinker 1991) proposes that regular words are read by a rule-based mechanism and that exception words are read by a lexical look-up procedure. Consistency effects (differential processing of words based on "neighboring" words of similar orthography) indicate, however, that neither regular words nor non-words are read by a rule-based procedure that is independent from lexical access. A connectionist model developed by Seidenberg & McClelland (1989) and improved by Plaut, et al. (1996) provides a single-mechanism alternative to the dual mechanism view that not only correctly reads both regular and exception words, but also cleanly accounts for consistency effects.

While consistency effects fall naturally out of the connectionist model, it has been less clear how such a model would account for the behavior of patients with acquired reading disorders. In one disorder, *surface dyslexia*, patients have relatively spared reading of regular words and nonwords, but poor reading of exception words (which are regularized) – as if the rule-based mechanism were intact but the lexical mechanism were damaged. Plaut, et al. (1996) note that surface dyslexia is often accompanied by severe semantic impairments and suggest that this disorder could be explained by a model that incorporates semantic representations, but they do not actually include a semantic layer in their model.

The Model

The current work adds a semantic representational layer to this model and demonstrates, in a network trained on a toy language called *Sheesh*, behavior consistent with surface dyslexia. Sheesh is constructed out of a minimal number of letters and sounds in order to keep the simulation tractable. Words in Sheesh are assigned pronunciations so that the spelling-sound mappings vary from completely regular, to regular but inconsistent (i.e. with a few inconsistent neighbors), to irregular—with proportions of each word type that approximate those found in English. The words are randomly assigned binary semantic representations. The architecture of the model is shown in Figure 1. Because

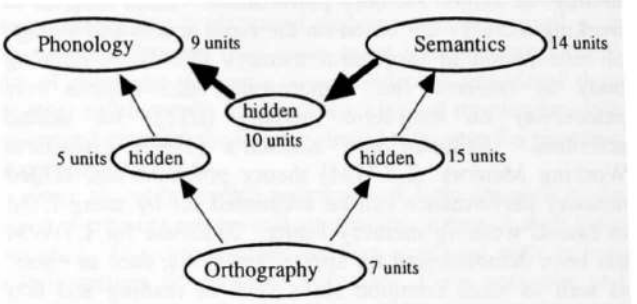

Figure 1: The architecture of the model.

children learn to speak before they learn to read, the weights from semantics to phonology (indicated with bold arrows) are pre-trained and fixed.

Results

With both pathways (orthography to phonology, and orthography to semantics to phonology) trained simultaneously, the network learns to read all of the words of Sheesh. When the semantic pathway is lesioned, but not when the phonological pathway is lesioned, the network shows selective impairment on exception words, as is seen in surface dyslexics. The model thus adds an additional line of support to the single mechanism view of word reading.

References

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