A Fully Connectionist Dual Route Model of Reading

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Introduction

There now exist direct route connectionist models of reading aloud (i.e. text to phoneme conversion) that can learn to perform on their training data and unseen words with accuracy comparable to that of humans (Bullinaria, 1994; Plaut et al., 1996). They also exhibit a number of developmental, reaction time and brain damage effects that are observed experimentally. These models also constitute an existence proof against earlier claims that separate routes are needed to process the regular and exception words. However, various deficiencies of these models (such as their inability to perform reliable lexical decision and their failure to exhibit the pseudohomophone effect) indicate the need to incorporate some form of lexical/semantic system into these models (e.g. Coltheart et al., 1993). Indeed, it has always been clear that such a sub-system will be needed in any complete model of reading and related tasks.

This work constitutes a preliminary investigation of the properties of these more complete connectionist models and their implications for understanding the normal reading process in children and adults, as well as both developmental and acquired reading disorders. A general framework is outlined that models the mappings between simplified representations of orthography, phonology and semantics on the appropriate network input-output units. The 'lexical entries' are distributed patterns of activation over these units. When presented with an input pattern, activation cascades via hidden units to the other two sets of output units by whichever route the gradient descent training procedure has learnt. Explicit small scale network simulations based on 513 mono-syllabic words show how such an approach can account for many aspects of reading (and related tasks) that are not possible without the influence of the semantic system. In particular, in addition to retaining all the main effects of the earlier single route models, we acquire the ability to perform accurate lexical decision with realistic reaction times (which show semantic and associative priming effects consistent with those found experimentally) and are able to exhibit the pseudo-homophone effect for naming latencies. Assuming, as with children, we teach our networks to map between phonology and semantics before we teach them to read and spell, we find that phonological recoding of the orthographic inputs automatically takes place when we look at the mapping from orthography to semantics. This agrees with what has been found experimentally (Van Orden et al., 1988) and has the important implication that (both developmental and acquired) phonological dyslexia (in which non-word performance is much worse than real word performance) must come about in a manner different to that generally assumed in conventional dual route models (e.g. Coltheart et al., 1993). Rather than occurring due to problems with the 'rule-based' orthography to phonology route, it must occur at some later phonological output processing stage as suggested by Patterson & Marcel (1992).

The success of these simple connectionist models suggests that we have a promising framework for the modelling of reading and also the related tasks of spelling, speech recognition, and so on. Moreover, we can see that many of the properties of this class of models are actually independent of the precise details of the models and hence we can expect to make the various aspects of them increasingly realistic without undoing our early successes. If we are to understand and remedy the problems that children face when learning to read (such as phonological dyslexia) we need to be sure that we are looking in the right place for those problems. The next stage of this work (in progress) is hence to consider more explicitly the text and speech input and output mechanisms and to investigate their properties when operating in conjunction with the models outlined here. We will then also be in a good position to model the emergence of morphological effects, time course effects, cross modal priming, and so on.

References

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