

Connectionist modelling of Chinese character pronunciation

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Introduction

Psychologists and cognitive scientists aim to understand the universals involved when the brain deals with written language. Seidenberg and McClelland's "triangle model" of the reading of monosyllabic English words has been substantially developed (e.g. Harm & Seidenberg, 1999), but with little application to languages other than English. Here we report our initial application of this approach to the reading of Chinese, a radically different orthography from English, illuminating processing universals in reading.

The granularity of Chinese orthography is a fundamental issue in modelling its pronunciation. The character is the unit of pronunciation. Several formats exist, but a central paradigm (the phonetic compound) exists in which a phonetic radical, usually on the right, specifies pronunciation information, and a semantic radical, usually on the left, specifies information about meaning (Fig. 1). Chen et al. (1996) argue that these radicals (plus any remaining sub-character material) are the functional processing units of Chinese reading. Therefore, the typical granularity is substantially coarser than that found in English orthography. Is there thus a principled architecture for modelling Chinese pronunciation that uses distributed representations in a non-trivial way? We resolve the issue by referring to the anatomy of the visual pathways.



Fig. 1: A Chinese character.

The split fovea

In recent years it has become clearer that the human fovea – across which a fixated word is projected on the retina – is precisely vertically split: the left of a fixated word initially projects to the right hemisphere and the right to the left hemisphere (Shillcock et al., 2000). Our model reflects this observation (Fig. 4). It is trained with a "fixation point" to the left, to the right, and in the middle of each character, so that each character is represented in three different positions (Fig. 2). Thus, superpositional storage occurs within each half of the model, in a psychologically realistic way.



Fig. 2: The pattern of fixations

Chinese phonetic compound database

Our Chinese lexicon database contains all phonetic compounds decomposed into semantic and phonetic radicals according to Chinese etymology (Harbaugh, 1998). In total, the database contains 3,028 phonetic compounds, of which 2,163 have their semantic and phonetic radicals forming a clear left-right structure. The majority of them have their phonetic radicals on the right (Fig. 3).

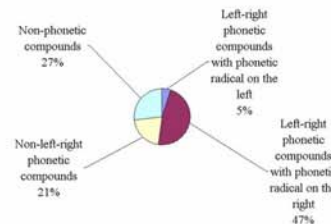


Fig. 3: Distribution of types of Chinese characters

The split-fovea model

Input units are localist representations of radicals. Of all the left-right structured phonetic compounds in the database, there are 252 different radicals on the left, and 857 on the right. Hence, in contrast to the information structure of English words, there is more variance on the right of Chinese characters. Some radicals can be further decomposed into other radicals. In total, there are 878 non-decomposable radicals. In the input layer, the radicals are all represented in each of the four positions necessary to accommodate the input schema shown in Fig. 2. Each position represents each of the 878 non-decomposable radicals. The input is mapped onto a feature-level phonological output. The necessary recurrence is implemented as "callosal" connections between

the two sets of hidden units – a further reflection of anatomical reality (Fig. 4).

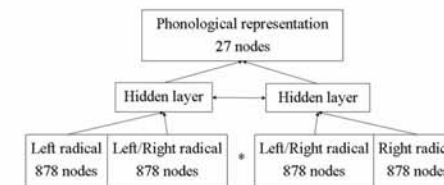


Fig. 4: The split model with callosal connections and fixation point.

Discussion

The model allows principled superpositional storage of the relations between sub-character orthographic units in the pronunciation of the entire character. There is a substantial localist aspect to the model, given the number of discrete nodes used. However, the model is able to capture the fact that different proportions of the set of radicals occur in different positions with respect to fixation, as shown in Fig. 2. The relationship between the orthography and its pronunciation is a challenge to modellers, given that the phonetic radical is only a useful guide to pronunciation in less than half of the characters. The model enables us to simulate the core data from experiments with characters presented centrally and in a single hemifield.

References

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