Investigating Serial Order and Graphemic Representations in Spelling: A Simple Recurrent Network Simulation

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Introduction

Current theories of spelling posit the existence of a working memory component or process known as the "graphemic buffer" (GB). The buffer is theorized to maintain the representation of the spelling of a word (retrieved from long-term memory) during the relatively slow, serial process of producing each letter.

Dysgraphic individuals with GB impairment exhibit characteristic error patterns. We investigate two of these patterns: 1) a bow-shaped serial position curve of letter accuracy, such that letters in the margins are more accurate than word-medial letters; 2) the preservation of the consonant-vowel identity of target letters in substitution errors. These error patterns bear on two important aspects of the functioning of the graphemic buffer: the serial order mechanism by which it produces each letter in the proper sequence and the nature of the representations it maintains.

Previous theories have accounted for the high rate of CV preservation by positing that graphemic representations explicitly encode consonant-vowel status. Buchwald & Rapp (in press) argued that the high rate of CV preservation could not be achieved solely through statistical knowledge of the spelling patterns of English (orthotactics). We attempt to supplement their findings by using neural networks to examine if knowledge of these statistical patterns is sufficient to account for the CV preservation data.

Turning to serial order, one type of theory that has been proposed known as *chaining theory* holds that serial order is achieved via inter-item associations. Many, if not all, of the previous letters in a word may serve as the cue for the next letter (e.g., Ebbinghaus, 1885). This study attempts to assess the degree to which *chaining* is an appropriate theory of the serial order mechanism of spelling by investigating if a particular neural network architecture which instantiates chaining can account for the two critical patterns described above.

To evaluate this hypothesis, we compared the errors made by simple recurrent networks (SRNs) to those made by dysgraphic individuals with GB deficits. An SRN is a type of neural network that is generally believed to operate via a chaining process. It learns sequences of items and then produces its output one element at a time rather than in parallel (Elman, 1990). SRNs are also highly sensitive to the statistical patterns present in their training data. This makes them an excellent vehicle for testing the orthotactic hypothesis of CV preservation as well providing a means of examining serial position curves.

Method

One hundred SRNs were trained to spell a corpus of 250 words (Experiment 1) and approximately 1800 words (Experiment 2). Dysgraphic performance was simulated individually by adding noise to one of four groups of weights until performance matched the overall letter accuracy of two dysgraphic individuals (BWN: 89.7%, RSB: 84.3%). The resulting responses were scored and compared to dysgraphic performance in a number of areas including: length effects, serial position effects, rate of consonant/vowel preservation, and behavior on doubled letters.

Results & Conclusions

Although the SRNs show length effects that are comparable to those of the dysgraphic subjects, there are very substantial discrepancies between SRN and dysgraphic performance on the other measures. This provides evidence that SRNs, and by implication, the mechanism of compound chaining may not be an appropriate theory of the serial order mechanism involved in spelling.

Acknowledgements

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References

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