

Representing Regularity: The English Past Tense

Matt Davis and William Marslen-Wilson

Centre for Speech and Language
Birkbeck College, University of London
Malet Street, London WC1E 7HX, UK.
m.davis@psyc.bbk.ac.uk w.marslen-wilson@psyc.bbk.ac.uk

Mary Hare

Center for Research in Language 0256
University of California, San Diego
La Jolla, California 92093, USA.
hare@crl.ucsd.edu

Introduction

For the last ten years, the English past tense has been an important test-case in the debate between rule-based and connectionist accounts of human language processing (Pinker, 1991; Rumelhart and McClelland, 1986). The work we report here focuses on a particular psychological property of regular and irregular past tense verbs; namely the demonstration that regularly inflected verbs prime their stems whereas irregular verbs do not (Marslen-Wilson, Hare and Older 1993; Stanners et al. 1979). This result has been interpreted as supporting a dual mechanism account (Pinker, 1991) in which the past tenses of regular verbs are generated by a rule-based mechanism, whereas irregular past tenses are stored in an associative memory system. Our purpose here is to investigate whether these representational differences between regular and irregular verbs can be accounted for by a single mechanism, connectionist model.

Network and Analysis

We trained a feed-forward network to map from a phonological representation of a stem or inflected verb to an abstract representation of the verb's semantics and tense. This task is analogous to the comprehension of the English inflectional morphology; the reverse of the mapping investigated by Cottrell and Plunkett (1991). The training set consisted of 988 English monosyllabic verbs (11.4% of which were irregular), with the network being trained on both stem and past tense forms. An additional 110 regular verbs were presented in one form only, to allow testing of the network's generalization abilities.

Following training the network generated the appropriate semantic vector and tense for over 97% of the verbs in the training set. The network also identified over 85% of the novel forms of familiar verbs, indicating that it was able to use the regular inflection productively.

To investigate the representations formed by the network, the hidden unit activations produced in response to regular and irregular verbs were recorded. Measuring the RMS difference between the pattern of activation produced

for stems and past tenses shows significant differences in the way that the network represents regular and irregular verbs. The representation of the past tense was more similar to the representation of the stem for regular than for irregular verbs. This difference was greater than would be expected on the basis of phonological similarity between verb stems and past tenses. Since the degree of overlap between two distributed representations correlates with the magnitude of priming observed in a network (Masson 1995), this finding provides a straightforward account of the reduced priming observed for irregular verbs.

The network therefore suggests that behavioral and representational differences between regular and irregular verbs need not imply different processing mechanisms.

References

- Cottrell, G. W. & Plunkett, K. (1991). Learning the past tense in a recurrent network: Acquiring the mapping from meanings to sounds. In *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society*. Hillsdale NJ: Lawrence Erlbaum Associates.
- Marslen-Wilson, W., Hare, M., & Older, L. (1993) Inflectional morphology and phonological regularity in the English mental lexicon. In *Proceedings of the Fifteenth Annual Conference of the Cognitive Science Society*. (pp. 693-698). Hillsdale NJ: Lawrence Erlbaum Associates.
- Masson, M. E. J. (1995). A distributed memory model of semantic priming. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 2(1), 3-23.
- Pinker, S. (1991). Rules of language. *Science*, 253, 530-535.
- Rumelhart, D. E., & McClelland, J. L. (1986). On learning the past tense of English verbs. In J. L. McClelland, D. E. Rumelhart and PDP Research Group (Eds), *Parallel distributed processing: Volume 2* (pp. 216-271). Cambridge, MA: MIT Press.
- Stanners, R. F., Neiser, J. J., Herson, W. P., & Hall, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior*, 18, 399-412.