

The role of learning mechanisms in understanding spoken words

Jennifer M Rodd (j.rodd@ucl.ac.uk)

Rebecca A Gilbert (becky.gilbert@ucl.ac.uk)

Hannah N Betts (hannah.betts.10@ucl.ac.uk)

Department of Experimental Psychology, University College London
26 Bedford Way, London, WC1H 0AP, UK

Abstract

Word meaning priming has become a key method to study how listeners (and readers) retune their lexical semantic representations in response to their linguistic environment in order to facilitate access to word meanings. We present a summary of recent findings using this method that help to constrain our theories of how this important form of lexical-semantic learning occurs.

Keywords: lexical ambiguity; semantic ambiguity; learning; speech; language

Background: Lexical Ambiguity

Access to word meanings during natural language comprehension is made difficult by the ubiquity of lexical ambiguity: 80% of common English words have multiple dictionary definitions (Rodd, Gaskell & Marlsen-Wilson, 2002). Take for example the first sentence of a reading comprehension text that was recently given to 11-year-old children in England: “Dawn was casting spun-gold threads across a rosy sky over Sawubona game reserve”. The words in this sentence have on average 8.8 dictionary definitions. The reader must work out that “Dawn” does not refer to a girl’s name and that “game” does not refer to a form of competitive sport. And they must realise that the words “casting” and “threads” are not referring to a physical action and object, but are instead being used in a somewhat metaphorical sense.

When a listener/reader encounters an ambiguous word, they usually rapidly retrieve the most appropriate meaning and ignore any other irrelevant meaning(s). A very large body of psycholinguistics experiments conducted over the last 40 years have provided important constraints on our understanding of how this disambiguation process operates. The literature has converged on the view, exemplified in the reordered access model (Duffy, Morris, and Rayner, 1988, see Vitello and Rodd, 2014 for review) that whenever a reader/listener encounters an ambiguous word, its multiple different meanings are activated in parallel, but this activation is modulated by the sentence context and the relative frequencies of the different meanings: meanings that are highly frequent or compatible with the preceding context are more readily available.

Word Meaning Priming: Published Findings

Recent studies using a novel word-meaning priming paradigm (Rodd et al., 2013; 2016) have supplemented this view of lexical disambiguation with evidence that learning

mechanisms make a key contribution to disambiguation fluency, by allowing listeners to make use of the past experience to boost the availability of meanings that are more likely to occur in the future. For example, comprehension of a sentence such as “the sheep were put into the pen”, is usually relatively difficult because the intended ‘animal-enclosure’ meaning of “pen” is far less frequent than the dominant ‘writing-instrument’ meaning. But learning mechanisms can make such sentences easier in conditions where the listener has increased prior experience with the lower frequency meaning.

Specifically, these word-meaning priming experiments have revealed the key role of recent experience in modulating the availability of word meanings. For example, if the lower-frequency meaning of “pen” is encountered as part of a sentence comprehension prime task, then this meaning will be more readily available after a 20-40 minute delay (compared with an unprimed control; Rodd et al., 2013; 2016). This form of word meaning priming does NOT reflect a general forms of semantic priming; a control condition in which participants were primed with different but synonymous words showed no priming at this relatively long delay (Rodd et al., 2013). Word-meaning priming only occurs when the specific ambiguous word (e.g., “pen”) is encountered in both the prime and test phases. In natural listening situations this dynamic ‘retuning’ of lexical-semantic representations will act to improve comprehension fluency for cases where an ambiguous word is encountered multiple times within the same conversation.

In addition to these lab-based experiments that have shown word-meaning priming at 20-40 minute delays (with little decay during this time window), experiments conducted with larger sets of participants outside the lab have shown that even larger priming effects occur as a consequence of naturalistic encounters with word meanings. For example when recreational rowers encounter the specific rowing-related meanings of common words like “catch” and “feather” during their training, a significant and numerically large priming effect was observed after a median delay of eight hours (Rodd et al., 2016). In addition, these relatively large effects of same-day experience with word meanings leave residual traces that accumulate incrementally over many years to alter a listener’s overall preferences for the different meanings: the number of years rowing experience that an individual rower had was a strong predictor of meaning access (Rodd et al., 2016).

Taken together, these results indicate that adult lexical-semantic representations are relatively fluid and are

constantly being retuned on the basis of experience to improve the fluency and accuracy of comprehension.

Word Meaning Priming: Recent Developments

A set of seven (unpublished) word-meaning priming experiments have been conducted to help constrain our theories of *how* exactly the availability of word meanings is boosted as a consequence of our experience.

Effects of prime/target modality. Two experiments (using different tasks at test) show that word-meaning priming occurs when the ambiguous words are presented in different modalities (i.e. spoken and written) at prime and test, and that such cross-modal priming is not reduced compared with uni-modal priming. This indicates that learning may occur at a relatively abstract lexical-semantic level, and that knowledge about words learned in one modality influences comprehension in the other modality.

Effects of word position. Two experiments (using different tasks at test) show that word-meaning priming is NOT modulated by the position of the ambiguous word within the sentence: there is no significant difference in priming when the disambiguating context occurs before or after the ambiguity (e.g., “the sheep were enclosed in a PEN” vs “a PEN was used to enclose the sheep”). These results are incompatible with an account where learning is triggered by the detection of an error signal that indicates that the ambiguous word has been misinterpreted, as this would predict increased priming for late-disambiguation sentences. The results are also incompatible with an account in which the co-activation of the word form and the contextually-appropriate drives learning: this would predict more priming for the early-disambiguation sentences. Instead the results indicate that lexical semantic representations are modulated on the basis of a word’s final, comprehended meaning and do not seem to be influenced by partial, transient activation of irrelevant meaning during comprehension.

Effects of multiple encounters. Three experiments show that listeners keep track of the likelihood of different meanings across multiple encounters with the ambiguous word. If the word is used repeatedly with the *same* meaning, the priming effects accumulate to increase the availability of this meaning relative to a single presentation control condition. In contrast, if different meanings are encountered then the effects of these experiences cancel each other out. Importantly, the cumulative effects of repeated exposure are dependent on the spacing of the words – no benefit of repetition is observed if the word is encountered multiple times in adjacent sentences.

Summary

Word meaning priming has become a key method to study how listeners (and readers) retune their lexical semantic representations in response to their linguistic environment.

We present recent findings using this method that help to constrain our theories of how this learning occurs and will guide the development of our connectionist model of how words are represented and processed (Rodd et al., 2004).

Acknowledgments

This work was supported by the Economic and Social Research Council [grant numbers ES/K013351/1; ES/L010224/1; ES/J500185/1]

Key Relevant Publications by the Author

(See jennirodd.com for full list)

Rodd, J. M., Berriman, R., Landau, M., Lee, T., Ho, C., Gaskell, M. G. et al. (2012a). Learning new meanings for old words: effects of semantic relatedness. *Memory and Cognition*, 40, 1095-1108.

Rodd, J. M., Cai, Z. G., Betts, H. N., Hanby, B., Hutchinson, C., & Adler, A. (2016). The impact of recent and long-term experience on access to word meanings: Evidence from large-scale internet-based experiments. *Journal of Memory and Language*, 87, 16-37.

Rodd, J. M., Davis, M. H., & Johnsrude, I. S. (2005). The neural mechanisms of speech comprehension: fMRI studies of semantic ambiguity. *Cerebral Cortex*, 15, 1261-1269.

Rodd, J. M., Gaskell, M. G., & Marslen-Wilson, W. D. (2004). Modelling the effects of semantic ambiguity in word recognition. *Cognitive Science*, 28, 89-104.

Rodd, J. M., Johnsrude, I. S., & Davis, M. H. (2010). The role of domain-general frontal systems in language comprehension: Evidence from dual-task interference and semantic ambiguity. *Brain and Language*.

Rodd, J. M., Johnsrude, I. S., & Davis, M. H. (2012). Dissociating frontotemporal contributions to semantic ambiguity resolution in spoken sentences. *Cerebral Cortex*, 22, 1761-1773.

Rodd, J. M., Lopez Cutrin, B., Kirsch, H., Millar, A., & Davis, M. H. (2013). Long-term priming of the meanings of ambiguous words. *Journal of Memory and Language*, 68, 180-198.

Rodd, J. M. (2004). The effect of semantic ambiguity on reading aloud: A twist in the tale. *Psychonomic Bulletin and Review*, 11, 440-445.

Rodd, J. M., Gaskell, M. G., & Marslen-Wilson, W. D. (2002). Making sense of semantic ambiguity: Semantic competition in lexical access. *Journal of Memory and Language*, 46, 245-266.

Vitello, S. & Rodd, J. M. (2015). Resolving Semantic Ambiguities in Sentences: Cognitive Processes and Brain Mechanisms. *Linguistics and Language Compass*, 9, 391-405.

Other References

Duffy, S. A., Morris, R. K., & Rayner, K. (1988). Lexical ambiguity and fixation times in reading. *Journal of Memory and Language*, 27, 429-446.