

Attentional Modulation of Lexical Effects in an Interactive Model of Speech Perception

Daniel Mirman, James L. McClelland, and Lori L. Holt

Center for the Neural Basis of Cognition and Psychology Department, Carnegie Mellon University, Pittsburgh, PA

Carnegie Mellon

Background

Lexical information can influence identification (e.g., Ganong 1980) and rate of recognition of phonemes (e.g., Rubin et al., 1976).

These influences have been found to be subject to attentional modulation due to task (e.g., Eimas, Hornstein, & Payton, 1990; Eimas & Nygaard, 1992) and stimulus list composition (e.g., Cutler, Mehler, Norris, & Segui, 1987; see also Pitt & Samuel, 1993).

The challenge

Lexical effects can be due to direct feedback from lexical processing to phonemic processing (as in the TRACE model, McClelland & Elman, 1986) or due to integration of lexical and phonemic information at a separate decision level (as in the Merge model, Norris et al., 2000).

Norris et al (2000) argued that an interactive model such as TRACE can not account for *variability* in lexical effects due to attentional modulation because lexical feedback is an intrinsic component of TRACE.

Goal

Implement a mechanism for attentional modulation of lexical influences on phoneme processing that is consistent with the interactive framework of the TRACE model.

Implementation

Implementation is based on the “biased competition” theory of attention (Desimone & Duncan, 1995), according to which, attention works as a bias on the competitive dynamics of processing.

TRACE: partially-active phonemes compete through lateral inhibition, this competition is biased by lexical feedback proportional to lexical activation. Strength of lexical influences on phoneme perception can be manipulated by a scaling factor on overall lexical activity. This scaling factor determines the responsiveness of lexical units to input.

Added an attentional scaling parameter (α) to the function specifying the change in activation for lexical unit a_i :

$$\Delta a_i = \alpha * \left(\underbrace{\sum a_p * W_{p \rightarrow i}}_{\text{Bottom-up phoneme} \rightarrow \text{lexical excitation}} + \underbrace{\sum a_l * W_{l \rightarrow i}}_{\text{Lateral lexical} \rightarrow \text{lexical inhibition}} \right)$$

Standard interactive activation function

When $\alpha=1.0$, model is equivalent to the original implementation of TRACE, when $\alpha < 1.0$, the lexical activation is dampened, thus reducing the lexical bias on phoneme processing, thus reducing lexical effects.

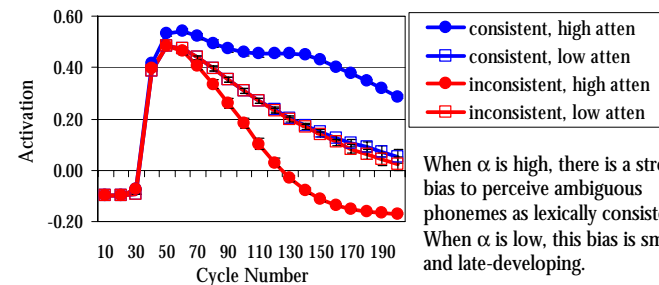
Simulation 1: Lexical identification shift

Behavioral findings

Ambiguous phonemes are perceived as lexically consistent (Ganong, 1980).

Phoneme identification shift is modulated by composition of stimulus list (Pitt & Samuel, 1993).

Simulation results



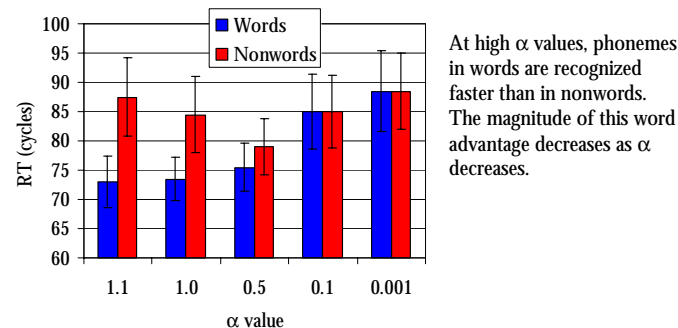
Simulation 2: Word advantage in phoneme monitoring

Behavioral findings

Phonemes are detected faster in words than nonwords (e.g., Rubin et al., 1976).

Word advantage is modulated by secondary tasks and stimulus list composition (Eimas et al., 1990; Eimas & Nygaard, 1992; Cutler et al., 1987).

Simulation results



Conclusions

An interactive model can account for attentional variability in lexical effects on phoneme processing.

Predictions

1. Conditions that reduce lexical effects should also reduce lexically mediated pre-lexical effects (e.g., selective adaptation induced by the Ganong effect, Samuel, 2001)
2. Neurophysiological markers of lexical/semantic processing (e.g., activation of BA 47) should be reduced under conditions that reduce lexical effects.

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Acknowledgements

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