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

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A number of studies have demonstrated that the strength of lexical effects on phoneme processing can be modulated by attention (e.g., Cutler et al., 1987; Eimas, Hornstein, & Payton, 1990; Vitevitch, 2003). The TRACE model (McClelland & Elman, 1986) posits direct feedback from lexical processing to phonemic processing, thus accounting for lexical influences on phoneme identification. However, the TRACE model lacks a mechanism for modulation of this feedback through attention. Some researchers (Norris, McQueen, & Cutler, 2000) have argued that this is a weakness of the interactive view of speech perception and is one reason to prefer an autonomous model.

We consider biased competition (Desimone & Duncan, 1995) as a possible attention mechanism that fits within the interactive framework of TRACE. In the context of TRACE, when an input is presented, phonemes that are partially consistent with the input compete through lateral inhibition. This competition is biased by lexical feedback proportional to the magnitude of lexical activation. Activation of lexical items is based on excitatory input from the phoneme layer and lateral inhibitory interactions among lexical items. The magnitude and rate at which lexical items become active can be manipulated by a scaling factor on the lexical units' response to input. This, in turn, influences the strength of lexical influences on phoneme perception. That is, task or stimulus conditions that cause participants to direct attention away from lexical processing may operate by causing a dampening of lexical layer activity and thereby reducing lexical biasing of phoneme processing. To implement this mechanism in TRACE, an attentional scaling parameter (α) was added to the function specifying the change in activation for lexical units for each processing cycle. When α=1.0, this is the standard TRACE model as implemented by McClelland and Elman (1986), when α<1.0, the lexical activation is dampened and lexical effects should be reduced.

This mechanism was tested in two cases of lexical effects on phoneme identification. Ambiguous phonemes tend to be perceived as lexically consistent (Ganong, 1980), but the strength of this effect varies with task and stimulus differences (see Pitt & Samuel, 1993, for review and meta-analysis). The attention parameter captured this variability. When lexical attention is high, lexical items become more active more quickly, thus providing stronger and earlier feedback to the phoneme level and biasing perception of the ambiguous acoustic input. When lexical attention is very low, lexical items become active more slowly, thus providing less feedback to the phoneme level and causing a small and late-developing lexical bias.

A second lexical effect on phoneme recognition is that phonemes are recognized more quickly in words than nonwords. This word advantage has also been shown to be affected by task and stimulus factors (e.g., Cutler et al., 1987). Variation of the attention parameter also captures this variability: at high α values, TRACE is faster to recognize phonemes that are embedded in words; at lower α values, the word advantage disappears. This is because lexical items are less active, thus they provide less support to their constituent phonemes.

The addition of a scaling parameter that dampens overall lexical layer activation provides a simple mechanism that works within the interactive framework of the TRACE model to modulate the strength of lexical influences on phoneme processing.

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