Computational Modeling of Spoken Language Processing

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Computational models provide a means for concretely specifying theoretical assumptions, and examining their complex interactions via simulation. Ideally, models help explain existing data and provide novel predictions that guide further research. Models have been particularly useful in the domains of speech perception and spoken word recognition, where theories and the signal are both complex. The TRACE model (McClelland & Elman, 1986) has the greatest breadth and depth of any model in those domains, and despite well-known shortcomings, continues to be used productively (e.g., to model time course data from eye movements). It also has much in common with other models characterized by activation-competition dynamics (e.g., Shortlist [Norris, 1994]). This makes TRACE ideal for introducing principles of computational modeling of spoken language processing.

In this full-day tutorial (with a half-day option), participants will learn skills for carrying out computational modeling of speech perception with TRACE. Experienced modelers will add new techniques to their repertoires. Participants will simulate speech experiments and link results to human data using the recently developed jTRACE tool (Strauss, Harris, & Magnuson, 2007). The tutorial will focus on two themes: principles of modeling, and linking model to human behavior.

1. Modeling speech perception with jTRACE

We will begin with a review of key previous work done with models of speech perception, emphasizing the symbiosis of behavioral and modeling techniques.

A tour of jTRACE's features will cover simulation visualizations, parameters, graphing, and archival features. Introduction to the TRACE model will focus on architectural features common to activation-competition models, as well as the temporal representation that is specific to TRACE.

Participants will implement simulations of behavioral phenomena selected from the review of previous work. Studies of increasing complexity will highlight elements of good modeling research and common pitfalls to avoid.

2. Linking model to behavior

Techniques will be taught for more sophisticated modeling projects, including scripting large batches of simulations, designing lexicons and stimuli, decision rules, and exploring model parameters (frequency, noise, priming, excitation and inhibition strength).

A detailed example will demonstrate the steps for modeling the time-course of word frequency effects as revealed by eye-tracking studies (Dahan, et al., 2001).

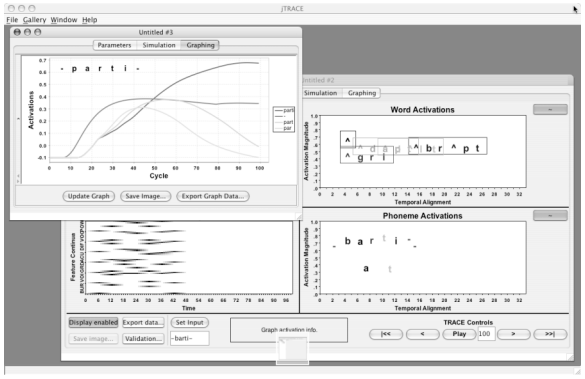

Figure 1: A screenshot of jTRACE.

The discussion of model interpretation will focus on specifying the link between model behavior and human behavior, including model-data linking hypotheses and decision rules. Understanding this connection is a step towards gauging the success or failure of a simulation. Four loci of model assessment will be discussed, providing examples from the literature: theoretical, implementational, parametric, and linking hypothesis.

At the end of the tutorial, participants will work in small groups on a modeling project applying the techniques learned during the tutorial. One-on-one modeling consultations will be available.

Prerequisites

No modeling experience is necessary. If possible, bring a laptop and install the free modeling tools in advance (from http://magnuson.psy.uconn.edu/jtrace).

References

Dahan, D., Magnuson, J. S., & Tanenhaus, M. K. (2001). Time course of frequency effects in spoken-word recognition: Evidence from eye movements. *Cognitive Psychology, 42*(4), 317-367.

McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology, 18*(1), 1-86.

Norris, D. (1994). Shortlist: A connectionist model of continuous speech recognition. *Cognition*, 52, 189-234.

Strauss, T. J., Harris, H. D., & Magnuson, J. S. (2007). jTRACE : A reimplementation and extension of the TRACE model of speech perception and spoken word recognition. *Behavior Research Methods, Instruments, and Computers*.