Computational Modeling of Spoken Language Processing: A hands-on tutorial

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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. In this tutorial, we will cover principles of conducting simulations, and assessing model success and failure. We will use the domain of spoken language processing for our examples. 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.

Participants will learn skills for carrying out computational modeling of speech perception with TRACE. Novices will be introduced to principles and practical aspects of using models, and can expect to leave the tutorial prepared to begin modeling their own data. 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 modeling software (Strauss et al., 2007).

1. Modeling speech perception with jTRACE

We will begin with a review of theories and models of speech perception, emphasizing the symbiosis of behavioral and modeling techniques, with particular focus on TRACE. We will then introduce features of jTRACE, including simulation visualizations, parameters, graphing, and archival features. Participants will learn by replicating classic TRACE simulations. Studies of increasing complexity will highlight elements of good modeling research and common pitfalls to avoid.

2. Linking model to behavior

We will cover techniques for sophisticated modeling projects, including scripting large batches of simulations, designing lexicons and stimuli, decision rules, and exploring model parameters. We cover methods for linking continuous output from a computational model to common tasks such as priming, naming, and lexical decision, and then turn to time course data, using a detailed example (the time-course of word frequency effects reported by Dahan, et al., 2001).

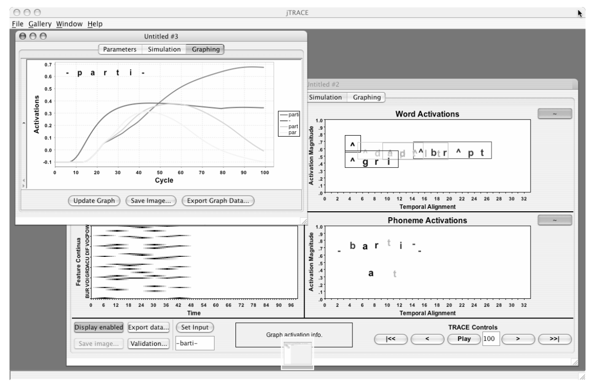

Figure 1: A screenshot of jTRACE.

The discussion of model interpretation will focus on specifying links between materials, task constraints, and measures used with human subjects and computational models. Understanding these connections is vital in gauging the success or failure of a simulation, and we will discuss diagnosing model successes and failures as attributable to four levels of analysis: theoretical, implementational, parametric, and linking hypotheses. 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*, 317-367.

McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology, 18*, 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, & Computers, 39*, 19-30.