Analysis Options in jTRACE

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1 Introduction

This document describes, in formal mathematical notation, the analysis options in the Graphing... Analysis... tab of jTRACE.

Words or Phonemes can be analyzed. Recall that for each cycle of the model, both of these matricies are two-dimensional. One dimension (the Y-axis on the graphs in the Simulation tab) is the item, a particular word or phoneme, and the other dimension (X-axis) is a time slice, indicating the model's representation of past, present, and future. To re-iterate, a time cycle is real time or model time, while a time slice is a spacial representation of time used internally in the model.

The content of an analysis can be either raw Activations or Luce Choice Rule (LCR) Response Probabilities. If the latter, then the Luce Choice options (described below) can be specified.

A subset of Items can be displayed. If Response Probabilities are used, probabilities are computed for only those words/phonemes.

The Alignment can be specified, where Alignment refers to which of the time slices is used for analysis. When Alignment is *Specified*, then only that time slice is used. For example, when preceded by the silence phone, '-', jTRACE words are generally activated at time slice 4, so setting *Specified* = 4 when graphing words will result in a graph of words that are aligned with the start of the utterance. If phonemes are being graphed, or parameters are changed, or more or less silence is used, or multiple words are present, other options may make more sense. *Average* alignment averages over all time slices, for each item. *Max (Ad-Hoc)* finds the best alignment for each item, for each time cycle. *Max (Post-Hoc)* finds the single best alignment for each word. The *Frauenfelder* rule is the average activation of the item at the specified and subsequent alignment, where only items that have time slices overlapping with the target item are potential responses. (This rule is a bit clearer mathematically than in words.)

2 Notation

R is a 3-D matrix of the raw data (either word or phoneme activations), $R_{c,i,s}$, where $c \in [0..C-1]$ is time cycle, and C is the total number of cycles, $i \in [0..I-1]$ is the item index, and I is the total number of items, and $s \in [0..S-1]$ is the time slice, and S is the total number of time slices. For example, $R_{2,3,4}$ is the raw activation of the 3rd item aligned with time slice 4, after 2 steps of the model.

R' is the response strength, calculated as $R' = e^{(\frac{R-min}{max-min})k}$, where min and max are the minimum and maximum node activation values, and $k \in \mathbb{N}$ is the usual exponent parameter used with the Luce Choice Rule.

P is the 2-D matrix of plottable data, the output of the analysis process, $P_{i,c}$, where $i \in [0..|w|-1]$, and $|w|$ is the number of specified items, and c is the time cycle, as above.

$w \subset 0, I-1$ is a set of indicies, selected by the user, to be plot, and indexed w_j.

$a \in 0..S-1$ is the specified alignment.

3 Analysis options

There are 3 possible analyses (Activations, Response Probabilities with Normal Choice, and Response Probabilities with Forced Choice), and 5 possible alignments (Average, Max (Ad-Hoc), Max (Post-Hoc), Specified, and Frauenfelder), giving 15 possible computations. They are the same for phoneme and word analyses, except as noted.

	Activations/*	RPs/Normal	RPs/Forced
Average	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{1}{S} \sum_{s=0}^{S-1} R_{c,w_j,s}.$	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{1}{S} \sum_{s=0}^{S-1} \frac{R'_{c,w_j,s}}{\sum_{i=0}^{I-1} R'_{c,i,s}}.$	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{1}{S} \sum_{s=0}^{S-1} \frac{R'_{c,w_j,s}}{\sum_{k=0}^{\lvert w \rvert} R'_{c,w_k,s}}.$
Max (Ad-Hoc)	$\forall i, 0 \le i < I, \forall c, 0 \le c < C,$ $a_{i,c} = \arg\max_a R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = R_{c,w_j,a_{w_j,c}}.$	$\forall i, 0 \le i < I, \forall c, 0 \le c < C,$ $a_{i,c} = \arg\max_a R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a_{w_j,c}}}{\sum_{\iota=0}^{I-1} R'_{c,\iota,a_{w_\iota,c}}}.$	$\forall i, 0 \le i < I, \forall c, 0 \le c < C,$ $a_{i,c} = \arg\max_a R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a_{w_j,c}}}{\sum_{k=0}^{\lvert w \rvert} R'_{c,w_k,a_{w_k,c}}}.$
Max (Post-Hoc)	$\forall i, 0 \le i < I$ $a_i = \arg\max_a \max_c R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = R_{c,w_j,a_{w_j}}.$	$\forall i, 0 \le i < I$ $a_i = \arg\max_a \max_c R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a_{w_j}}}{\sum_{i=0}^{I-1} R'_{c,i,a_{w_j}}}.$	$\forall i, 0 \le i < I$ $a_i = \arg\max_a \max_c R_{c,i,a},$ $\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a_{w_j}}}{\sum_{k=0}^{\lvert w \rvert} R'_{c,w_k,a_{w_k}}}.$
Specified	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = R_{c,w_j,a}.$	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a}}{\sum_{i=0}^{I-1} R'_{c,i,a}}.$	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{R'_{c,w_j,a}}{\sum_{k=0}^{\lvert w \rvert} R'_{c,w_k,a}}.$
Frauenfelder	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{1}{2}(R_{c,w_j,a} + R_{c,w_j,a+1}).$	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{(R_{c,w_j,a} + R_{c,w_j,a+1})}{2 \sum_{i=0}^{I-1} \sum_{q=\lambda_i}^{\rho_j} R'_{c,i,q}},$ where $\lambda_i = a - \text{length}(w_i)$, and $\rho_j = a + \text{length}(w_j)$ ($\text{length}(w_*) = 1$ for phonemes)	$\forall j, 0 \le j < \lvert w \rvert, \forall c, 0 \le c < C,$ $P_{j,c} = \frac{(R_{c,w_j,a} + R_{c,w_j,a+1})}{2 \sum_{k=0}^{\lvert w \rvert} \sum_{q=\lambda_k}^{\rho_j} R'_{c,i,q}},$ where $\lambda_k = a - \text{length}(w_k)$, and $\rho_j = a + \text{length}(w_j)$ ($\text{length}(w_*) = 1$ for phonemes)