

## SPM fitting algorithms and pseudo code

A technical difficulty in using joint models can be getting them to actually run and produce results (known as “obtaining convergence”). Higher order models like SPMs require “iterative fitting” algorithms that start with initial parameter estimates and then iteratively improve them until a stopping criterion is reached (convergence). The biggest tip we can give is that the better the initial estimates are when starting the estimation procedure, the higher the chance that the fitting algorithms will converge and produce realistic estimates for the SPM. Here we provide pseudo-code of a stepwise approach that generally works in finding decent initial parameter estimates for SPM fitting. Depending on the size and structure of your data and the statistical package you use, fewer (or more) substeps may be necessary. Recall the basic form of the SPM:

### Basic Shared Parameter Model:

#### 1. *Longitudinal (LDA) submodel:*

Outcome over time = predictors + *latent characteristics*

#### 2. *Censoring (EVENT) submodel:*

$\log(\text{Event hazard}) = \text{baseline hazard} + \text{predictors}$   
+ loading factors \* (*latent characteristics*)

Shared Information

### General SPM Pseudo-Code:

- Step 0: Conduct any **data curation** needed for the specific statistical package being used
- Step 1: Obtain **initial LDA estimates**: Fit the LDA mixed model **separately** and obtain initial estimates of:
  - LDA submodel regression parameters ( $\beta$ ),
  - variance parameters ( $\tau, \sigma$ ), and
  - latent characteristics for each subject/id (empirical Bayes estimates:  $b_{0i}$ ,  $b_{1i}$ , etc.)
- Step 2: Obtain **Initial EVENT estimates**: Fit the Weibull survival model **separately**, using the empirical Bayes estimates from Step 1 as additional predictors, and obtain initial estimates of:
  - EVENT submodel regression parameters ( $\alpha$ ),
  - Baseline hazard shape parameters ( $\lambda_0(t)$ ), and
  - loading factors from latent characteristics ( $\rho$ )
- Step 3: **Improve Initial estimates**: Fit the **joint SPM**, initializing the parameter estimates from Steps 1 and 2 above, **but still using the calculated empirical Bayes estimates** from Step 1 as predictors in the EVENT submodel, to obtain better initial estimates of all sub-model parameters.
- Step 4: Obtain **final SPM estimates**: Fit the **joint SPM**, initializing all parameter estimates from Step 3. In this final step, do not include the calculated empirical Bayes estimates from Step 1 as predictors, but instead treat them as full latent constructs.

Each individual statistical package may require additional sub-steps within each of these general steps.