**SPLH 861 HW5: Introduction to Crossed Random Effects Models (9 points total)  
Due Friday 10/31/2014 by 11:59 PM via Blackboard  
Revision Due by Friday 11/14/14 by 11:59 PM via Blackboard  
  
Please submit all relevant files (word document, syntax, and output)  
using this naming convention: 861\_Firstname\_Lastname\_HW5**

**General Instructions:**

This homework features data from yet another study conducted at Midwestern Red State University, this time examining the effects of individual differences and toy differences on toy enjoyment ratings. Fifty children were each given the opportunity to play with the same 24 toys and were asked to give enjoyment ratings for each toy (rated on a scale of 0 to 20; mean ~10, SD ~3). The toys were either educational or not, or considered to be fun or not (as was determined by prior research with the same population), such that there were 6 toys for each fun by educational combination. IQ scores were also collected for each child (mean ~10, SD ~2).

Your task is to estimate the models listed below within MIXED using restricted maximum likelihood. In this assignment three new quantities will be requested from you:

1. The term *specific effect size* used below refers to Pseudo-R2 for the variance component that *should be targeted* by the new fixed effect(s), which is calculated as Pseudo-R2 = (variancefewer – variancemore) / variancefewer, in which *fewer* represents the model with fewer parameters and *more* represents the model with additional new parameters.  
   Pseudo-R2 should be reported as a signed value (e.g., if the variance went up instead of down, Pseudo-R2 will actually be negative).
2. Test statistics for the change in model fit should be reported from a likelihood ratio test using this format: −2ΔLL(df) = value, *p* = *p*-value, in which df = degrees of freedom for the model comparison (the number of parameters different between models), value = difference in −2LL between models, and the *p*-value comes from a χ2 distribution using χ2 = value and the model comparison df (as can be found using CHIDIST in excel or LRTEST in STATA). Report *p*-values with no numbers showing as *p* < .001.
3. 95% random effects confidence intervals can be calculated for any random effect (i.e., any model term that each sampling unit gets their own of via a combination of a fixed and random effect) as follows: CI = fixed effect ± 1.96\*SQRT(random variance).

Center your predictors such that the reference toy is not fun (fun = 0) and not educational (educ = 0), and the reference person has IQ = 100. For this assignment it will be easiest to treat the two binary toy predictors as “continuous” via manual dummy codes, but you may also treat them as “categorical” instead if you wish so long your reference groups remain as instructed. All values should be reported to the nearest .01 to be correct; in SAS, make sure to refer to the “iteration history” table to find the model −2LL given to two significant digits. Use an alpha level of *p* < .05 to denote significant effects.

After answering each set of questions, you will then complete a results section about the model by inserting the answers you found where needed and selecting the correct answer out of the list of possible choices below **[leave the bold text and brackets in please]**:

**[PROGRAM]** = program you used to complete this assignment  
**[LRT]** = result of corresponding −2LL test **[VALUE]** = corresponding value calculated separately  
**[EST]** = corresponding fixed effect estimate (coefficient)  
**[A]** = significantly or nonsignificantly   
**[B]** = better or worse  
**[C]** = higher or lower  
**[D]** = more positive, less positive, more negative, less negative  
**[E]** = the simple main effect of toy fun-ness, the simple main effect of toy educational-ness,   
 the interaction of toy fun-ness by toy educational-ness  
**[F]** = child random intercept variance, toy random intercept variance, residual variance  
**[G]** = liked educational toys more, liked educational toys less, disliked educational toys more,   
 disliked educational toys less

**Section 1**

The purpose of section 1 is to quantify the sources of variance in enjoyment ratings before considering any effects of predictors. Begin with an empty model with only a single residual variance (for which you should get −2LL = 5236.142, fixed intercept = 9.8890).

**Questions:**

1. Is there significant variance across children in enjoyment ratings? To find out, add a random intercept variance across children to the model, and record the test statistic for the change in model fit:
2. Is there significant variance across toys in enjoyment ratings? To find out, add a random intercept variance across toys to the model, and record the test statistic for the change in model fit:
3. What is the total amount of variance in enjoyment ratings from summing all three sources (residual, children random intercept variance, toy random intercept variance)?
4. What proportion of the total variance is due to mean differences between children?
5. What proportion of the total variance is due to mean differences between toys?
6. What proportion of the total variance is due to the interaction of child by toy?
7. What is the average toy enjoyment rating across all children and toys?
8. What is the 95% random effect CI for rating mean differences between children?
9. What is the 95% random effect CI for rating mean differences between toys?

**Results:**

The extent to which toy and child characteristics predicted the enjoyment of different kinds of toys was examined with mixed models in which children and toys were modeled as crossed random effects. Models were estimated using restricted maximum likelihood within **[program]**. Accordingly, improvements in model fit resulting from new variance components were examined via likelihood ratio tests with degrees of freedom equal to the number of additional parameters, whereas the significance of fixed effects was evaluated using Wald tests (i.e., the *p*-value for the ratio of each estimate to its standard error).

An empty means model with no fixed effects of predictors or random effects was first estimated as a baseline. First, the addition of a random intercept variance for children resulted in **[A B]** model fit, **[LRT]**. Second, the addition of a random intercept for toys resulted in **[A B]** model fit, **[LRT]**. In this crossed random effects model, **[VALUE]**% of the outcome variation was due to mean differences in enjoyment ratings between children, **[VALUE]**% of the outcome variation was due to mean differences in enjoyment ratings between toys, and **[VALUE]**% of the outcome variation was due to the unique pairing of child and toy. Based on these results, the mean toy enjoyment rating across the sample was predicted to be **[EST]**, with a 95% confidence interval for mean differences across children of **[VALUE]**, and mean differences across toys of **[VALUE]**. This empty means, crossed random effects model was used as the unconditional baseline to which fixed effects were then added, as described next.

**Section 2**

The purpose of section 2 is to describe how toy enjoyment ratings differed as an interactive function of the toy predictor variables of fun-ness and educational-ness. Add these fixed effects to your previous model (new −2LL = 4298.811) and answer the questions below.

**Questions:**

1. Were fun toys given higher ratings than not-fun toys if they were not educational?   
   Report the relevant fixed effect, SE, and *p*-value:
2. Were fun toys given higher ratings than not-fun toys if they were educational?   
   Report the relevant fixed effect, SE, and *p*-value:
3. Were educational toys given higher ratings than not-educational toys if they were not fun?  
   Report the relevant fixed effect, SE, and *p*-value:
4. Were educational toys given higher ratings than not-educational toys if they were fun?  
   Report the relevant fixed effect, SE, and *p*-value:
5. Did the effect of toy fun-ness differ by toy educational-ness?  
   Report the relevant fixed effect, SE, and *p*-value:
6. Did the effect of toy educational-ness differ by toy fun-ness?  
   Report the relevant fixed effect, SE, and *p*-value:
7. Report the *specific effect size* (see instructions on p. 1) for these toy fixed effects relative to the last model in section 1:

**Results:**

The extent to which the toy characteristics of fun-ness and educational-ness interacted to predict toy enjoyment ratings was then examined. These three fixed effects reduced the **[F]** by **[VALUE]%**.

First, for not-educational toys, toys that were fun were rated **[A C]** by **[EST]** than toys that were not fun, whereas for educational toys, toys that were fun were rated **[A C]** by **[EST]** than toys that were not fun. As such, the effect of toy fun-ness was **[A D]** for educational toys than for non-educational toys, as indicated by **[E]**.

Second, for not-fun toys, toys that were educational were rated **[A C]** by **[EST]** than toys that were not educational, whereas for fun toys, toys that were educational were rated **[A C]** by **[EST]** than toys that were not educational. As such, the effect of toy educational-ness was **[A D]** for fun toys than for non-fun toys, as indicated by **[E]**.

**Section 3**

The purpose of section 3 is to explore how child IQ moderates the effects of toy type. To answer questions 17 and 18, begin by adding ONLY a main effect of child IQ to your previous model (new −2LL = 4298.735). Then, to answer the rest of the questions, continue by adding fixed effects to allow \*each\* of the previous effects of toy type to be moderated by child IQ (new −2LL = 4295.203).   
*(Side note: in practice you would have examined random slopes prior to this step as other new variances to be predicted, but for simplicity and speed of estimation we will not do so here).*

**Questions:**

1. Do smarter kids like the toys better on average?   
   Report the relevant fixed effect, SE, and *p*-value:
2. Report the *specific effect size* for the effect of child IQ fixed effect relative to the last model in section 2:
3. (After adding the IQ moderation effects as instructed above )  
   Report the *specific effect size* for how child IQ moderates the effects of toy type relative to the previous model in this section with only a main effect of child ID:
4. What is the effect of toy educational-ness for not-fun toys for a child with IQ = 10?  
   Report the relevant fixed effect, SE, and *p*-value:
5. What is the *difference per unit IQ* in the effect of toy educational-ness for not-fun toys?  
   Report the relevant fixed effect, SE, and *p*-value:
6. What is the effect of toy educational-ness for fun toys for a child with IQ = 10?  
   Report the relevant fixed effect, SE, and *p*-value:
7. What is the *difference per unit IQ* in the effect of toy educational-ness for fun toys?  
   Report the relevant fixed effect, SE, and *p*-value:
8. What is difference between not-fun and fun toys in how each unit of IQ moderates the effect of toy educational-ness? Report the relevant fixed effect, SE, and *p*-value:

**Create Table 1:** complete the table template below with the results of the final model including all fixed effects and variance components (with separate columns for their estimate, standard error, and p-value). Make sure each model effect is clearly labeled.  
  
**Create Figure 1:** create predicted toy ratings for a child with either IQ = 8 or IQ = 12 for each of the four combinations of toy fun-ness by educational-ness (8 predicted ratings total). Plot the predicted ratings on the y-axis (scaled from 0 to 20) against child IQ on the x-axis (scaled from 8 to 12) with separate lines for each of the four toy types.

**Results:**

The extent to which child IQ (centered such that 0 = 10) moderated the interactive effects of toy fun-ness and toy educational-ness on toy enjoyment ratings was then examined. A main effect of IQ was first examined, which revealed that toy enjoyment ratings were **[A C]** by **[EST]** per unit IQ. This fixed main effect of IQ reduced the **[F]** by **[VALUE]%**.

Moderation of the toy effects by IQ was then examined by adding interactions of IQ by toy fun-ness, toy educational-ness, and IQ by fun by educational to the model, which reduced the **[F]** by **[VALUE]%**. As shown in Figure 1, the moderation by child IQ of the effect of toy educational-ness was **[A D]** for fun toys than not-fun toys and can be interpreted as by describing how the effect of toy educational-ness varies by toy fun-ness and child IQ as follows. Full model results are reported in Table 1.

First, when evaluated for an average child (IQ = 10), not-fun toys that were educational were rated **[A C]** by **[EST]** than not-fun toys that were not educational. This toy educational-ness effect became **[A D]** for every additional unit of child IQ, such that smarter children **[G]** than non-educational toys if they were not fun.

Second, when evaluated for an average child (IQ = 10), fun toys that were educational were rated **[A C]** by **[EST]** than fun toys that were not educational. This toy educational-ness effect became **[A D]** for every additional unit of child IQ, such that smarter children **[G]** than non-educational toys if they were fun.

**[Insert Figure 1]**

Table 1

*Results from final crossed random effects model including toy and child predictors*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model Parameter |  | Est | SE | *p* < |
|  |  |  |  |  |
| Fixed Effects (should be 8) |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variance Components (should be 3) |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |