Announcements

- Homework due as a pdf on Blackboard, by **MIDNIGHT FRIDAY DEC 18**.
- This assigment and the associated data are in the "hw05" area of the class website.

The Problem And The Data

Ivan Jimenez is a composer and musicologist at the University of Pittsburgh. Dr. Jimenez and a student, Vincent Rossi, collected data in a designed experiment inteneded to measure the influence of instrument, harmonic motion, and voice leading on listeners' identification of music as "classical" or "popular".

They presented 36 musical stimuli to 70 listeners, recruited from the population of undergraduates at the University of Pittsburgh, and asked the listeners to rate the music on two different scales:

- How classical does the music sound (1 to 10, 1 = not at all, 10 = very classical sounding);

- How popular does the music sound (1 to 10, 1 = not at all, 10 = very popular sounding).

Listeners were told that a piece could be rated as both classical and popular, neither classical nor popular, or mostly classical and not popular (or vice versa), so that the scales should have functioned more or less independently.

The 36 stimuli were chosen by completely crossing these factors:

Instrument: String Quartet, Piano, Electric Guitar

Harmonic Motion: I-V-vi, I-VI-V, I-V-IV, IV-I-V

Voice Leading: Contrary Motion, Parallel 3rds, Parallel 5ths

The researchers' main hypotheses were roughly these:

- Instrument should have the largest influence on rating;

- One particular harmonic progression, I-V-vi, might be frequently rated as classical, because it is the beginning progression for Pachelbel's *Canon in D*, which many people have heard. On the other hand, it is also a very common chord progression in popular music of the past 20 years or so (so common that comedy bits have been written about it, e.g. `http://www.youtube.com/watch?v=oOlDewpCfZQ`).

- Based on previous research, it was expected that contrary motion would also be frequently rated as classical.

A powerpoint presentation exploring the data (looking at cell means only, no model fits) is available in the subdirectory "presentation" in the "hw05" area of the website, in which some of these ideas are explored more fully[1]. You can also click on and listen to some of the stimuli in the powerpoint presentation[2].

A brief description of all variables in the data set follows:

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[1]The data set you will be working with is slightly different from the one in the powerpoint presentation, so not all numerical summaries will be the same.

[2]You will have to download the directory, and enable access to external content in the dialog box at the beginning of the presentation, to hear the stimuli during the presentation.

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Classical                          How classical does the stimulus sound?
Popular                            How popular does the stimulus sound?
Subject                            Unique subject ID
Harmony                            Harmonic Motion (4 levels)
Instrument                         Instrument      (3 levels)
Voice                              Voice Leading   (3 levels)
Selfdeclare                        Are you a musician? (1-6, 1=not at all)
OMSI                               Score on a test of musical knowledge
X16.minus.17                       Auxiliary measure of listener's ability to
                                      distinguish classical vs popular music
ConsInstr                          How much did you concentrate on the
                                      instrument while listening (0-5, 0=not
                                      at all)
ConsNotes                          How much did you concentrate on the
                                      notes while listening? (0-5, 0=not at
                                      all)
Instr.minus.Notes                  Difference between prev. two variables
PachListen                         How familiar are you with Pachelbel's Canon
                                      in D (0-5, 0=not at all)
ClsListen                          How much do you listen to classical music?
                                      (0-5, 0=not at all)
KnowRob                            Have you heard Rob Paravonian's Pachelbel Rant
                                      (0-5, 0=not at all)
KnowAxis                           Have you heard Axis of Evil's Comedy bit on
                                      the 4 Pachelbel chords in popular music?
                                      (0-5, 0=not at all)
X1990s2000s                        How much do you listen to pop and rock from
                                      the 90's and 2000's? (0-5, 0=not at all)
X1990s2000s.minus.1960s1970s       Difference between prev variable and a
                                      similar variable referring to 60's
                                      and 70's pop and rock.
CollegeMusic                       Have you taken music classes in college
                                      (0=no, 1=yes)
NoClass                            How many music classes have you taken?
APTheory                           Did you take AP Music Theory class in
                                      High School (0=no, 1=yes)
Composing                          Have you done any music composing (0-5,
                                      0=not at all)
PianoPlay                          Do you play piano (0-5, 0=not at all)
GuitarPlay                         Do you play guitar (0-5, 0=not at all)
X1stInstr                          How proficient are you at your first
                                      musical instrument (0-5, 0=not at all)
X2ndInstr                          Same, for second musical instrument
first12                            In the experiment, which instrument was
                                   presented to the subject in the first
                                   12 stimuli? (IGNORE FOR THIS ASSIGNMENT.)
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The data is in the file "ratings.csv" in the hw05 area of the class website. While the data is fairly clean and well-organized, there are a few anomalies that you will have to decide what to do with as you work through data analyses. If

you encounter any of these anomalies, please say how you dealt with each of them (including, possibly, not changing the data at all).

Exercises

Note: *There are several ways to attack each question below, e.g., some questions may have a Bayesian answer as well as a non-Bayesian answer. Except where explicitly noted, you will get full credit for choosing a single suitable method and applying and interpreting it correctly, regardless of whether there is another method that also might work.*

1. *The three main experimental factors.*

   (a) Examine the influence of the three main experimental factors (Instrument, Harmony & Voice) on Classical ratings, using conventional linear models and/or analysis of variance models. Comment briefly on your findings, providing suitable brief evidence for each result. *Hint: To determine whether Harmony is important, for example, one might compare the fit of a model with Harmony in it, to one without Harmony. To determine how particular kinds of harmony affect ratings, one might begin by looking at fixed effects estimates in a suitable model. Etc.*

   (b) Since we have approximately 36 ratings from each participant, we can fit a random intercept for each participant if we wish. Such a model is called a "repeated measures" model.

      i. Carefully write this model in mathematical terms as a hierarchical linear model.

      ii. Use at least two different methods to test whether the random intercept is needed in the model. Is the random effect needed? Justify your answer with evidence from your tests.

      iii. Re-examine the influence of the three main experimental factors (Instrument, Harmony & Voice) on Classical ratings, using the repeated-measures model with the random intercept for participants[3].

   (c) The random intercept in a repeated measures model can account for "personal biases" in ratings: perhaps person A is more inclined to rate everything as classical, and person B is more inclined to rate everything as popular. This can be accounted for by the random intercept. Alternatively, perhaps personal biases vary with the type of instrument, type of harmony, and/or type of voice leading. For example, perhaps people vary in the degree to which they are inclined to call music played by a string quartet "classical". This suggests, e.g., a random effect of the form `(1|Subject:Instrument)`: a random draw is made from a single normal distribution, for each person/instrument combination. One could argue for a similar random effect for each person/harmony combination, and for each person/voice leading combination.

      i. Determine whether a model with all three new random effect terms (but not the original single random intercept) is better or worse than each of the models in problems 1a and 1b. Provide suitable evidence to justify your answer.

      ii. Re-examine the influence of the three main experimental factors (Instrument, Harmony & Voice) on Classical ratings, using the model with all three new random effect terms in it. Comment briefly on your findings, providing suitable brief evidence for each result. In addition, comment on the sizes of the three estimated variance components, with respect to each other and with respect to the estimated residual variance.

      iii. Carefully write this model in mathematical terms as a hierarchical linear model.

   Because they are design variables in the experiment, the three experimental factors, Instrument, Harmony, and Voice, should be included in all models for the remainder of this homework, regardless of what you found about their influnce or lack of influence on ratings.

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   [3]I do not think there will be much difference between a REML analysis and a maximum likelihood analysis here. If there is a difference, please report results for this part using maximum likelihood.

2. *Individual covariates.* For this problem, begin with your best model from problem 1.

   (a) Determine which individual covariates should be added to the model as fixed effects. Show a suitable summary of your work, and list the final set of variables that you would include in the model. *Hint: Some covariates that are actually factor variables are coded as numeric. Be careful to treat them as factors!*

   (b) Once the fixed effects are settled, go back and check to see whether there should be any change in the random effects. Provide suitable evidence to justify your answer.

   (c) Briefly interpret the effect of each variable kept in the final model, on Classical ratings.

3. *Musicians vs. Non-musicians.* One of the secondary hypotheses of the researchers is that people who self-identify as musicians may be influenced by things that do not influence non-musicians. Dichotomize "Self-declare" ("are you a musician?") so that about half the participants are categorized as self-declared musicians, and half not. Examine and report on any interactions between the dichotomized musician variable and other predictors in the model. Provide suitable evidence for, and comment on, your results.

4. *Classical vs. Popular.* Please re-examine the data in terms of the "Popular" ratings, instead of the "Classical" ratings, using similar hierarchical linear models. Provide brief answers to the following questions:

   (a) Comment on the influence of Instrument, Harmony & Voice on Popular ratings, providing suitable brief evidence for each result.

   (b) Question 2c, for Popular ratings.

   (c) Question 3, for Popular ratings.

5. *Brief writeup.* Write a one page professional-quality summary of your findings for Classical and Popular ratings, suitable for Dr. Jimenez. Be sure to address:

   • The influence of the three main experimental factors (Instrument, Harmony & Voice);

   • A brief discussion of variance components—is this a standard repeated measures model, or did we need to include other variance components?

   • A discussion of other indivdual covariates in the model.

   You may refer to your earlier work (e.g. "As I showed in my answer to part 1b, blah-blah-blah. . . "). Don't be sloppy about the statistical findings, but try to highlight things that will be of substantive interest to Dr. Jimenez. Make your summary very readable and clear.