

This Lab shows you how to analyze a CRF experiment using PROC MIXED and WinBUGS. Your job is to run PROC MIXED to get the basic output and to use tTailArea.xls to compute relevant posterior probabilities. The SAS program will resemble Figure 8.13 (run three times with different response variables in the Model statement). Instructions on how to do the posterior probability calculations can be found at the end of this document.

Download the data:

The data set is available at the the textbook website at the "computer exercises" link.

- Right click on "NineMonthAudio.xls" and save it in a convenient place such as C:\temp\.
- Start SAS, click in the editor window.

Import the Excel file into the SAS "file cabinet":

Type this program in the SAS editor window and run it (see textbook section C.3.2 for details).

```
PROC IMPORT DATAFILE="C:\TEMP\NineMonthAudio.xls"
  OUT=NineMo
  DBMS=EXCEL REPLACE;

RUN;
```

Open the "work" drawer of the file cabinet and examine the contents of the file called "NineMo" that you just created. It should have 81 rows (each row contains data for one cochlear implant patient) and 12 variables:

SubNum	Patient ID number
Age	Patient's age at the time of implantation
Device	Type of cochlear implant (A/B/G3)
YrDeaf	Years of profound deafness prior to implantation
Month	Months of experience with the implant (9 months in this data set)
CS	Consonant recognition score, sound only.
CV	Consonant recognition score, visual only (no sound).
CSV	Consonant recognition score, sound and vision.
SNT	Sentence understanding score.
VOW	Vowel recognition score.
WRD	Word recognition score.
PHN	Phoneme recognition score.

Data Description

Subjects received one of three different brands of cochlear implant (1/2/3). Brand 3 is a third generation device, brands 1 and 2 are second generation devices. The research question is to determine whether the three brands provide different levels of speech recognition.

Assignment

Run separate analyses of these three response variables, which are different tests of speech recognition:

1. CSV, Audiovisual consonant recognition (subjects hear triads like "ABA" "ATA" "AFA" and have to pick the correct consonant on a touch screen).
2. PHN, Phoneme understanding (number of correct phonemes in random 5 to 7 word sentences like "The boy threw the ball").
3. WRD, Word recognition (number of words recognized in a list of random, unrelated monosyllabic words "ball", "dog", etc).

Analyze the first Response Variables:

Use PROC MIXED (see textbook section 8.6.1 and Figure 8.12 for details). Type in the following program and run it; i.e., highlight from "PROC" to "RUN" and click the runner logo.

```

PROC MIXED DATA=ninemo;
  CLASS device;
  MODEL csv=device / DDFM=SATTERTH;
  REPEATED / GROUP=device;
  LSMEANS device / DIFF CL;
RUN;

```

Locate the Relevant Parts of the Output:

Least Squares Means

Effect	Device	Estimate	Standard Error	DF	t Value	Pr > t	Alpha	Lower	Upper
		\bar{x}	SEM	ν				LCL	UCL
Device	A	37.0375	4.4482	23	8.33	<.0001	0.05	27.8356	46.2394
Device	B	41.1321	3.5815	23	11.48	<.0001	0.05	33.7232	48.5410
Device	G3	63.7558	3.7426	32	17.04	<.0001	0.05	56.1323	71.3792

Differences of Least Squares Means

Effect	Device	Device	Estimate	Standard Error	DF	t Value	Pr > t	Alpha	Lower	Upper
			$\hat{\Delta}$	SED	ν	t-val	p-val		LCL	UCL
Device	A	B	-4.0946	5.7109	44.0	-0.72	0.4772	0.05	-15.6041	7.4149
Device	A	G3	-26.7183	5.8132	49.3	-4.60	<.0001	0.05	-38.3985	-15.0380
Device	B	G3	-22.6237	5.1802	54.2	-4.37	<.0001	0.05	-33.0084	-12.2389

Notice that the differences are expressed in alphabetical order, rather than the preferred order (larger – smaller). Therefore, in preparing your report, you will need to reverse the signs of $\hat{\Delta}$, LCL, and UCL. Thus:

Device	B	A	4.0946	5.7109	44.0	-0.72	0.4772	0.05	<u>-7.4149</u>	<u>+15.6041</u>
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(Notice that UCL and LCL change places after the sign reversal)

Analyze the other two response variables using this code to analyze the sentence and word scores:

<pre> PROC MIXED DATA=NineMo; CLASS device; MODEL phn = device / DDFM=SATTERTH; Repeated / GROUP = device ; LSMEANS device / DIFF CL; RUN; </pre>	<pre> PROC MIXED DATA=NineMo; CLASS device; MODEL wrd = device / DDFM=SATTERTH; REPEATED /GROUP = device LSMEANS device / DIFF CL; RUN; </pre>
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Here is background material that you can use to help write the background and methods sections of your report. Feel free to search for additional background information on cochlear implants (what are they, how do they work, what kind of condition do they cure ...). However, it is not necessary to write a long paper – 3 to 5 pages is quite sufficient.

In phase 1 of the cochlear implant project, 50 profoundly deaf subjects were alternately assigned to two second-generation, multi-channel cochlear implants (A or B); one subjects dropped out of group 1 and 1 from group 2 before the nine month follow-up. Five years later, in phase 2, a series of subjects with medical histories similar to the above group was implanted with a third generation device (G3). Subjects' speech recognition was tested at periodic follow-up visits after connection of the device. At the time this data set was compiled, 33 subjects in this group had completed the nine-month follow-up. The data consist of various speech recognition measures (including consonant recognition and word and sentence understanding) at approximately nine months after electrical connection of the device.

The consonant test consisted of 20 presentations of 11 consonants presented in the form "ABA", "ATA", etc; subjects responded on a touch screen and received a percent correct score. The word test consisted of 100 monosyllabic words, subjects wrote what they thought they heard and received a percent correct score. The sentence test consisted of 30 5 to 7 word sentences. Subjects wrote what they thought they heard and were scored on percent words correct.

The first generation devices had different speech processing strategies and different numbers of electrodes in the cochlea, the third generation device uses a different and more sophisticated processing strategy as well as different programmable choices of the mode of stimulation of the nerve. It was expected to be a clinically important improvement over the second generation devices.

The investigator wants to determine if the two second generation devices are clinically equivalent, i.e., if there is strong evidence that they differ by less than 4 points and whether the third generation device is clinically superior; i.e., if it is at least 8 points better than either first generation device.

Your computing assignment is to use SAS PROC MIXED to compute the approximate posterior mu, sigma, and df for the difference between each pair of devices for each response variable. Then compute the approximate posterior probability that devices A and B are equivalent and the posterior probability that device C is superior to A and to B.

Follow this general form for your report.

Introduction. This section is typically a review of the literature and a statement of the purpose of the research project covered by this paper. You may paraphrase the relevant parts of the above description of the study.

Methods. Describe how the data were analyzed.

Results. Presents the statistical results in tables and describe the contents of the tables in words. Say which differences are statistically significant / insignificant and which are clinically important or not (I.e., which devices are clinically equivalent (no important difference) and which are clinically superior (an important difference)).

Here is a suggested form for your three tables.

Sentences					95% CI			
Device	n	estimate	std err	df	lower	upper		
A	xx	xx.x	x.x	xx	xx.x	xx.x		
B	xx	xx.x	x.x	xx	xx.x	xx.x		
G3	xx	xx.x	x.x	xx	xx.x	xx.x		
B vs A		xx.x	x.x	xx	xx.x	xx.x	0.xxx	n/a
G3 vs A		xx.x	x.x	xx	xx.x	xx.x	0.xxx	0.xxx
G3 vs B		xx.x	x.x	xx	xx.x	xx.x	0.xxx	0.xxx

Table 1. Sentence understanding means and pairwise differences.

Conclusions. Say whether the results provide strong answers to the research questions of equivalence and superiority.

How to do the posterior probability calculations.

Suppose the B vs A analysis produces an Estimate ($\hat{\Delta} = \mu$) = 5.01, standard error (σ) = 5.98, and $df = 43$. The probability that the two devices are clinically equivalent is $P(-4 < \Delta < 4 | \text{Data}) = P(\Delta < 4) - P(\Delta < -4)$. To calculate this quantity, first convert +4 and -4 into Z-values: +4 converts to $z = (4 - 5.01) / 5.98 = -0.1689$ and -4 converts to $z = (-4 - 5.01) / 5.98 = -1.507$. Use tTailArea.xls like this to calculate the two tail areas and take the difference:

$P(\Delta < 4) = 0.4333$			$P(\Delta < -4) = 0.0696$		
Tail areas for t(df)			Tail areas for t(df)		
	$v = df =$	43		$v = df =$	43
	$t = z =$	-0.1689		$t = z =$	-1.507
Left Tail	$P(t(df) \leq z) =$	0.4333	Left Tail	$P(t(df) \leq z) =$	0.0696
Right Tail	$P(t(df) > z) =$	0.5667	Right Tail	$P(t(df) > z) =$	0.9304

$P(-4 < \Delta < 4 | \text{Data}) = P(\Delta < 4) - P(\Delta < -4) = 0.4333 - 0.0696 = 0.3637$, thus there is only 37.4% probability that devices A and B are clinically equivalent; the odds *against* equivalence are about 2 to 1.

To calculate the probability that Δ is bigger than zero, $P(\Delta > 0)$, convert 0 to a z-value and use `ttailarea.xls`. The z-value conversion is $z = (0 - 5.01)/5.98 = -0.838$. According to `ttailarea.xls` the right tail is 0.7967. Thus there is about an 80% chance that the difference is positive. This would be regarded as fairly weak evidence of positivity.

Additional work that would enhance the report would be to verify that the three groups are similar with respect to age and duration of deafness.