Anova for Repeated Measures and Skewed Response Variable: Two Examples from Medical Fields

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I- Effects of Velocity and Direction of Exerting Pressure on Ear Canal Admittance of a Tympanogram

A. Research Problem: A tympanogram is the plotted acoustic admittance measures(mho) versus exerted ear canal pressure (Pa).It is plotted for each person and has many parameters. One of them is ear canal admittance (**ECA**).
The aim is to study the behavior of ECA (**response variable**) under the following conditions (**explanatory variables**):
(1) **gender :** 2-levels, **M**=male, **F**=female . (2) **ear :**2-levels, **R**=right ear, **L**=left ear.
(3) **direction** (of exerting pressure) **:** 2-levels,**U**=Up(min to max),**D**=Down(max to min).
(4) **prssure.velocity :** 4-levels,**50,100,200,400** (daPa/s).
This is a repeated measure problem with **16** observation per case (4x2x2) i.e. ,
pressure.velocity * direction * ear.
B. Result Expectations: As ECA is also equivalent ear canal volume; It is expected that its behavior is constant under different conditions, except for gender.
C. R-Solution
a: Computational Solution: aov() with "error term"=Error(cases)
As a repeated measures problem we have to create the column of **cases(**1 to 60),each value being repeated 16 times. With no interaction found, the final format of **aov( )** is:
> aov(ECA~(pressure.velocity+gender+direction+ear+Error(cases))
b: Graphical Solution: interaction.plot( )
Three categorical variables of gender, ear and direction were combined into a single factor, named **GED** with eight levels. Therefore, we have the following format:
> interaction.plot(pressure.velocity,GED,ECA)

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II. Residual Analysis of a Skewed Response Variable

A. Research Problem: There is a lymphocyte ratio of CD4 (helper) counts to CD8 (suppressor or killer) counts. It is used to evaluate the immune status of patients.
The aim is to show the behavior of CD4/CD8 ratio (**CD4.CD8** is our **response variable**) for three types of pulmonary diseases, i.e. we have a 3-level factor variable (**disease**).
B. Result Expectations: It is expected that average value of CD4/CD8 ratio is different for different pulmonary diseases; and hence this ratio can be used as a differential test among these three types of pulmonary diseases.
C. R-Solution
a. Computational: aov( ) , glm(…,family=Gamma,…)
Since the response variable is a ratio, its distribution is highly skewed. The assumption of normality is violated;further,the residuals from a simple anova are far from being normal.
With using glm(…,family=Gamma,…), the distribution of residuals becomes normal.
> summary(result.glm<-glm(CD4.CD8 ~ disease, family=Gamma))
> summary(result.aov<-aov(CD4.CD8 ~ disease))
b. Graphical: hist( ),boxplot( )
> **hist(CD4.CD8);hist(result.glm$resid);hist(result.aov$resid)**
> boxplot(CD4.CD8 ~ disease)

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