Distraction Study

In a study of the psychology of attention, subjects attempted to solve word problems while listening to distracting background noise. The distracting material was either music, or spoken words related to the problem they were trying to solve. The distracting material was presented at three different levels of loudness. Each subject attempted 10 problems at each combination of loudness and type of distraction, for a total of 60 problems. Order of presentation was randomized. Data for each subject are number correct in each of the six treatment combinations. Carry out the appropriate two-factor analysis, obtaining F-tests for differences among the 6 treatment means (this is the overall test), and also for both main effects and the interaction. Follow up the analysis to see where the effects come from.

```
> # Distraction Data
>
> rm(list=ls())
> distract <-
read.table("http://www.utstat.toronto.edu/~brunner/appliedf14/code_n_data/lecture/distract.data",
header=T)
> distract[1:5,]
  LowVoice MedVoice HighVoice LowMusic MedMusic HighMusic
1        3        5         0        5        6         5
2        6        5         3        7        9         9
3        2        3         2        7        5         6
4       10        7         8        7        8         9
5        6        5         1        7        7         8
> attach(distract)
> # Look at cell means
> Xbar = apply(distract,2,mean); Xbar
 LowVoice  MedVoice HighVoice  LowMusic  MedMusic HighMusic
    5.555     4.520     3.530     6.535     6.425     6.555

> V = Xbar[1:3]; M = Xbar[4:6]
> cellmeans = rbind(V,M)
> rownames(cellmeans) <- c("Voice","Music")
> colnames(cellmeans) <- c("Low","Medium","High")
> cellmeans
        Low Medium  High
Voice 5.555  4.520 3.530
Music 6.535  6.425 6.555

> # Marginal Means
> apply(cellmeans,1,mean)
Voice Music
4.535 6.505
```

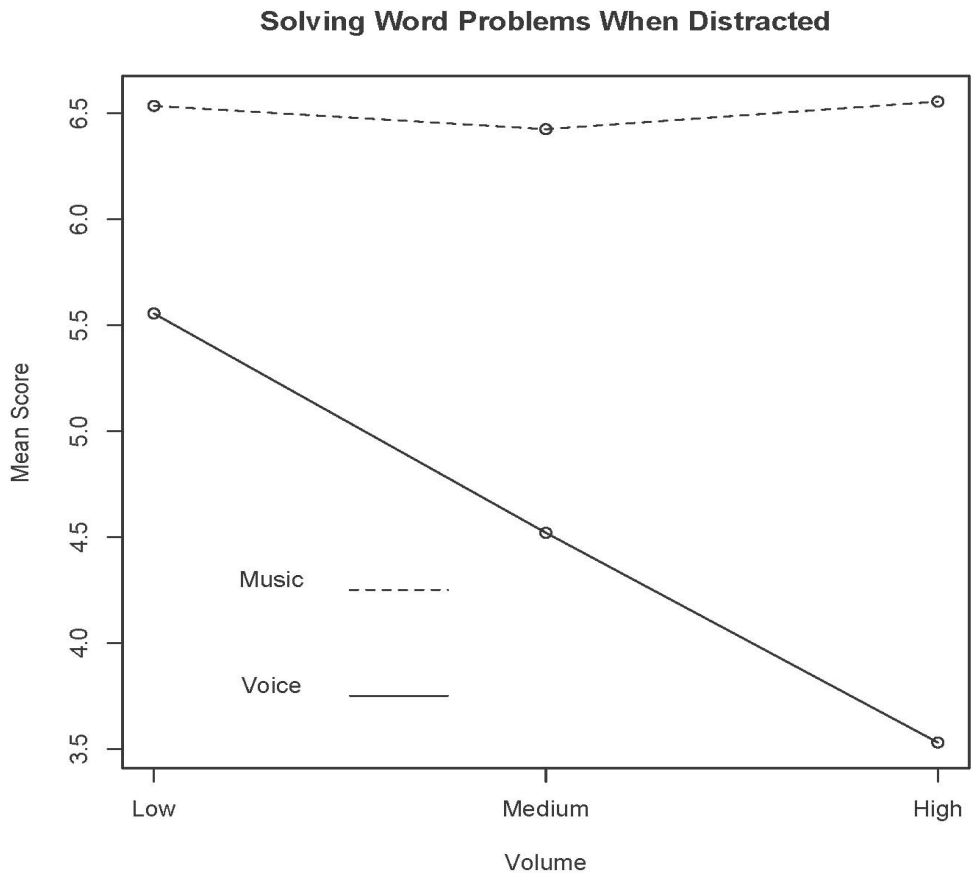
```
> apply(cellmeans,2,mean)
   Low Medium   High
6.0450 5.4725 5.0425
> # Time for some tests
> # Hotelling's T-squared for H0: L mu = h
> HTest = function(datta,L,h=0)
+     {
+     HTest = numeric(5)
+     names(HTest) = c("T-squared","F","df1","df2","p-value")
+     xbar = apply(datta,2,mean)
+     n = dim(datta)[1]; k = dim(datta)[2]; r = dim(L)[1]
+     if(dim(L)[2] != k) stop("L and data matrix incompatible sizes")
+     T2 = n * t(L%*%xbar-h) %*% solve(L%*%var(datta)%*%t(L)) %*% (L%*%xbar-h)
+     T2 = as.numeric(T2); F = (n-r)/(r*(n-1)) * T2
+     pval = 1-pf(F,r,n-r)
+     HTest = c(T2,F,r,n-r,pval)
+     names(HTest) = c("T-squared","F","df1","df2","p-value")
+     round(HTest,5)
+     } # End function HTest
>
> # Overall test for equality of 6 MEANS
> L0 = rbind(c(1,0,0,0,0,-1),
+            c(0,1,0,0,0,-1),
+            c(0,0,1,0,0,-1),
+            c(0,0,0,1,0,-1),
+            c(0,0,0,0,1,-1) )
> HTest(distract,L0)
T-squared         F       df1       df2   p-value
 757.2930  148.4142    5.0000  195.0000    0.0000
>
> # Main effect of Voice vs. Music
> L1 = rbind(c(1,1,1,-1,-1,-1))
> HTest(distract,L1)
T-squared         F       df1       df2   p-value
 567.3154  567.3154    1.0000  199.0000    0.0000
>
> # Just a matched t-test
> voice = (LowVoice+MedVoice+HighVoice)/3
> music = (LowMusic+MedMusic+HighMusic)/3
> t.test(voice,music,paired=T)

      Paired t-test

data:  voice and music
t = -23.8184, df = 199, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.133099 -1.806901
sample estimates:
mean of the differences
                  -1.97

> t.test(voice,music,paired=T)$statistic^2
       t
567.3154
>
> # Main effect of Volume (Low Medium High)
> L2 = rbind(c(1,-1,0,1,-1,0),
+            c(0,1,-1,0,1,-1)  )
> HTest(distract,L2)
T-squared         F       df1       df2   p-value
111.03230  55.23718   2.00000 198.00000   0.00000
>
```

```
> # Interaction (Maybe not this way)
> L3 = rbind(c(1,-1,0,-1,1,0),
+            c(0,1,-1,0,-1,1))
> HTest(distract,L3)
T-squared         F       df1       df2   p-value
120.29697  59.84623   2.00000 198.00000   0.00000
>
> L4 = rbind(c( 1,-1, 0,-1, 1, 0),
+            c( 0, 1,-1, 0,-1, 1))
> HTest(distract,L4)
T-squared         F       df1       df2   p-value
120.29697  59.84623   2.00000 198.00000   0.00000
>
> # Plot the means
> x <- 1:3
> plot(c(x,x),Xbar, xlab = "Volume",ylab = "Mean Score",xaxt='n')
> axis(side=1,at=1:3,labels=colnames(cellmeans))
> lines(x,V,lty=1)
> lines(x,M,lty=2)
> title("Solving Word Problems When Distracted")
> x1 <- c(1.5,1.75) ; y1 <- c(3.75,3.75) ; lines(x1,y1,lty=1)
> text(1.3,3.8,"Voice")
> x2 <- c(1.5,1.75) ; y2 <- c(4.25,4.25) ; lines(x2,y2,lty=2)
> text(1.3,4.3,"Music")
>
```



```
> # Follow-up tests
>
> # Is the drop in performance from low to medium volume different for
> # Music and Voice?
> L5 = rbind(c(1,-1,0,-1,1,0))
> HTest(distract,L5)
T-squared         F       df1       df2   p-value
  25.4537   25.4537    1.0000  199.0000    0.0000
>
> # Is the drop in performance from medium to high volume different for
> # Music and Voice?
> L6 = rbind(c(0,1,-1,0,-1,1))
> HTest(distract,L6)
T-squared         F       df1       df2   p-value
 32.52197  32.52197   1.00000 199.00000   0.00000
>
> # All pairwise comparisons
> # Set up Matrix
> pairz = diag(6)
> rownames(pairz) = names(Xbar); colnames(pairz) = names(Xbar)
> pairz
          LowVoice MedVoice HighVoice LowMusic MedMusic HighMusic
LowVoice         1        0         0        0        0         0
MedVoice         0        1         0        0        0         0
HighVoice        0        0         1        0        0         0
LowMusic         0        0         0        1        0         0
MedMusic         0        0         0        0        1         0
HighMusic        0        0         0        0        0         1
> # Fill with p-values
> for(i in 1:5)
+     {for(j in (i+1):6)
+         {pairz[i,j] = t.test(distract[,i],distract[,j],paired=T)$p.value}
+     }
> round(pairz,6)
          LowVoice MedVoice HighVoice LowMusic MedMusic HighMusic
LowVoice         1        0         0        0 0.000000  0.000000
MedVoice         0        1         0        0 0.000000  0.000000
HighVoice        0        0         1        0 0.000000  0.000000
LowMusic         0        0         0        1 0.385098  0.880780
MedMusic         0        0         0        0 1.000000  0.313448
HighMusic        0        0         0        0 0.000000  1.000000
```