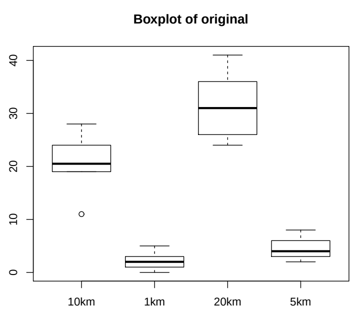
1. (a) The variances of the 1km and 5km groups seems noticeably smaller than that for the other groups.

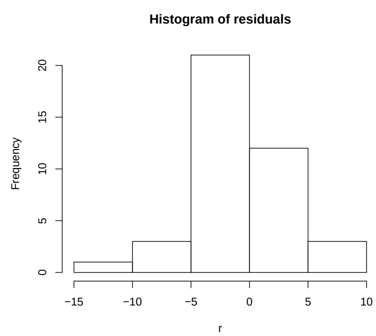
   (b) Since sample sizes are equal, and the residuals look reasonably normal (plot below), we may use the Hartley test here. The test statistic is $\max s_i^2 / \min s_i^2 = 30.49/2.18 = 13.99 > 6.31 = h_{4,9}(.05)$. So, we have significant evidence to reject the assumption of equal area group variances.

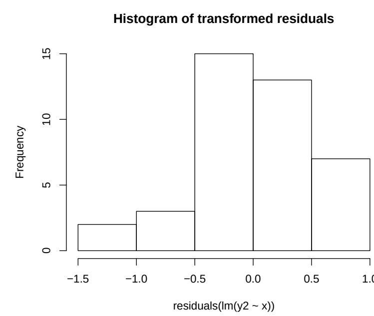
   (c) With the sqrt data, the histogram of the residuals does not appear normal, so we consider the Brown-Forsythe test, which is ANOVA on the transformed data $d_{ij} = |\sqrt{Y_{ij}} - \sqrt{\tilde{Y}}_i|$. The results show very little evidence against the equal variance assumption for the sqrt data (p-value 0.9989).

```
y2 = sqrt(y)
y2med = tapply(y2,x,median)
d = abs(y2-rep(y2med,each=10))
anova(lm(d~x))
```

   (d) The residual plot of the transformed data is in the third plot below. It appears to be left-skewed slightly and less normal than the original data.







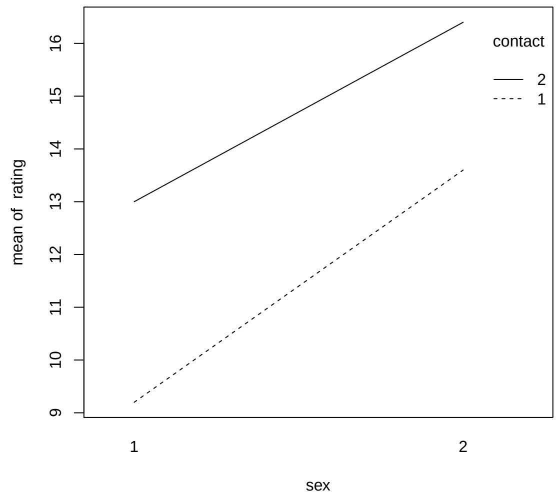
2. (a) By inspection, we find that the overall mean $\mu_{\cdot\cdot}$ is 8, and the effects $\alpha_i = \mu_{i\cdot} - \mu_{\cdot\cdot}$ and $\beta_j = \mu_{\cdot j} - \mu_{\cdot\cdot}$ are given by $\alpha = [0, 2, -2]$, and $\beta = [2, -3, 1, 0]$.

   (b) Since each mean μ_{ij} is the sum of the components $\mu_{\cdot\cdot} + \alpha_i + \beta_j$, there is no interaction. For example, $\mu_{11} = 10 = 8 + 0 + 2 = \mu_{\cdot\cdot} + \alpha_1 + \beta_1$, and this holds for all i and j.

3. (a) Similar to 2. above, we calculate $\mu_{\cdot\cdot} = 8$, $\alpha = [0, 2, -2]$, and $\beta = [4/3, -5/3, -1/3, 2/3]$.

   (b) In this case, the additive property does not hold for all i and j. For example $\mu_{11} = 8 \neq 8 + 0 + 4/3 = \mu_{\cdot\cdot} + \alpha_1 + \beta_1$. So, there is interaction present.

4. (a) The plot below shows very little evidence of contact by sex interaction. The lines appear very nearly parallel, which suggests that the effect of contact is the same for both sexes.



(b) The ANOVA obtained with `anova(lm(rating~contact+sex+contact*sex))`:

```
Response: rating
            Df Sum Sq Mean Sq F value   Pr(>F)
contact      1  54.45  54.450  8.9630 0.008589 **
sex          1  76.05  76.050 12.5185 0.002734 **
contact:sex  1   1.25   1.250  0.2058 0.656202
Residuals   16  97.20   6.075
```

(c) The test statistic for interaction is $0.2058 < 4.49 = f_{1,16}(.05)$, which is not significant evidence.

(d) From the ANOVA table above, we see that both main effects are significant (p-values less than 0.05). It is meaningful to test main effects in this case because without interaction, we may safely average over the sexes to test for contact effects, and to average over contacts to test for sex effect. Without interaction, the effect of one does not depend on the level of the other.