2-exploration_analyses.R

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```
library(ggplot2)
library(ggthemes)
suppressPackageStartupMessages(library(dplyr))
```

```
## Warning: package 'dplyr' was built under R version 3.4.1
```

```
library(stringr)
library(reshape2)
library(knitr)
library(xtable)
suppressWarnings(library(lubridate))
```

```
##
## Attaching package: 'lubridate'

## The following object is masked from 'package:base':
##
##     date
```

```
dat <- read.csv("data/data-ready.text", sep = "|", check.names = F)
```

Split quant. data into groups for time, satisfaction, and preference

```
dat.time <- dat[c("participant-number", "house-type", "t1", "t2", "t3", "t4", "t5")]
names(dat.time) <- c("p", "h", "shelf", "list", "fb", "m_return", "fb_return")
dat.satisfaction <- dat[c("participant-number", "t1q", "t2q",
                          "t3q", "t4q", "t5q", "house-type")]
names(dat.satisfaction) <- c("p", "shelf", "list", "fb", "m_return", "fb_return", "h")
dat.preference <- dat[c("participant-number", "q1", "q2", "q3", "q4", "house-type")]
names(dat.preference) <- c("p", "machine_usefulness",
                           "fb_usefulness", "shelf_vs_list", "app_vs_fb", "h")
dat.error <- dat[c("participant-number", "house-type")]
```

Create data.frame for Errors from observed data. t1e is task 1 errors, t2e is task 2 errors.

```
error <- data.frame(c(8245, 2589, 466, 5115, 9893, 1557, 46, 5511,
                      2757, 7994, 2105, 9500, 3682, 7019, 5665, 2747),
                    c(0, 0, 0, 1, 2, 0, 0, 0, 0, 0, 0, 2, 0, 0, 0, 2),
                    c(2, 2, 2, 0, 3, 0, 2, 0, 2, 1, 2, 2, 2, 2, 0, 0))
names(error) <- c("p", "t1e", "t2e")
names(dat.error) <- c("p", "h")
dat.er <- merge(dat.error, error)

# Plots for most important measures
means.time <- melt(dat.time[2:5] %>%
  group_by(h) %>%
  summarise_all(mean))
```

```
## Using h as id variables
```

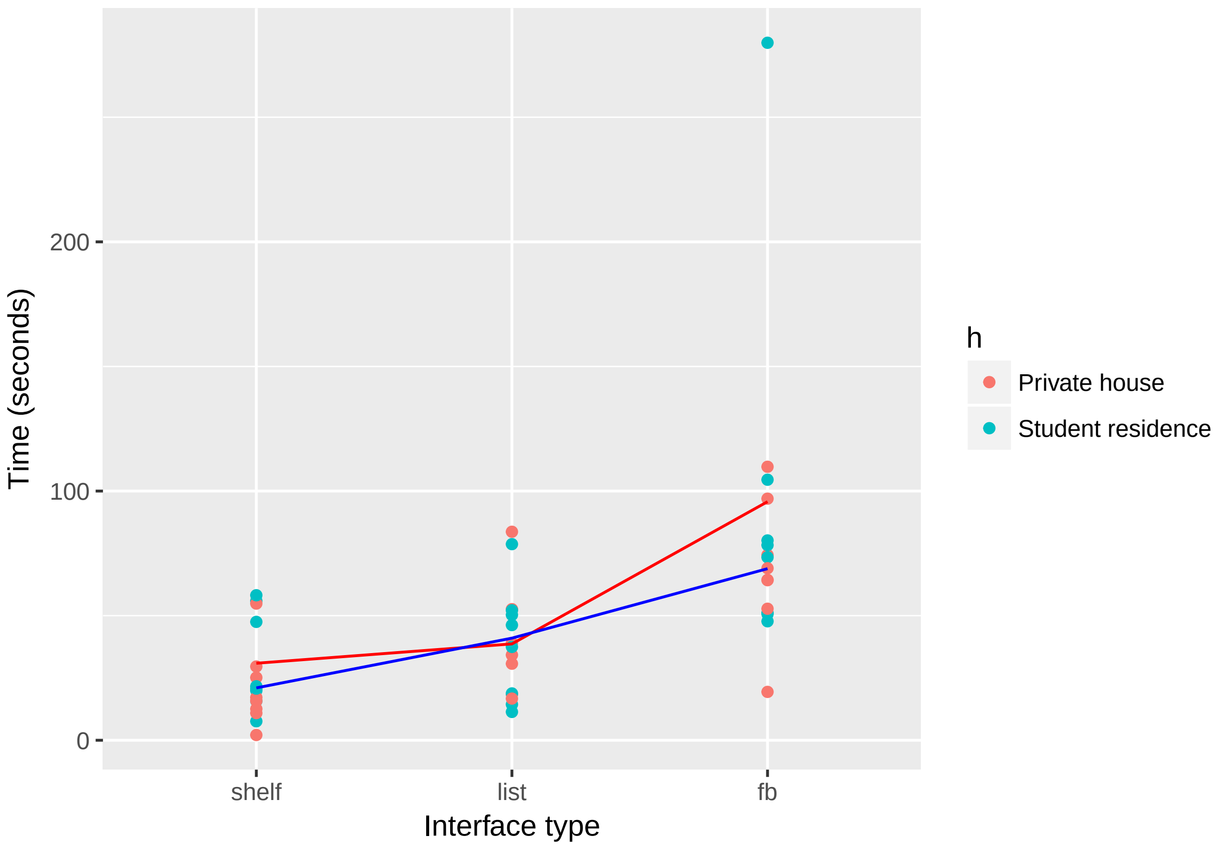
```r
means.time.sr <- subset(means.time, h == "Student residence")
means.time.pr <- subset(means.time, h == "Private house")
```

Time for borrow tasks with different interface type

```r
ggplot(melt(dat.time[2:5]),aes(x=variable,y=value, color=h)) +
  geom_point() +
  stat_summary(data = means.time.sr, aes(y = value), colour="red", geom="line", group=1)+
  stat_summary(data = means.time.pr, aes(y = value), colour="blue", geom="line", group=2)+
  ylab("Time (seconds)") + xlab("Interface type")
```

```
## Using h as id variables
```

```
## No summary function supplied, defaulting to `mean_se()
## No summary function supplied, defaulting to `mean_se()
```



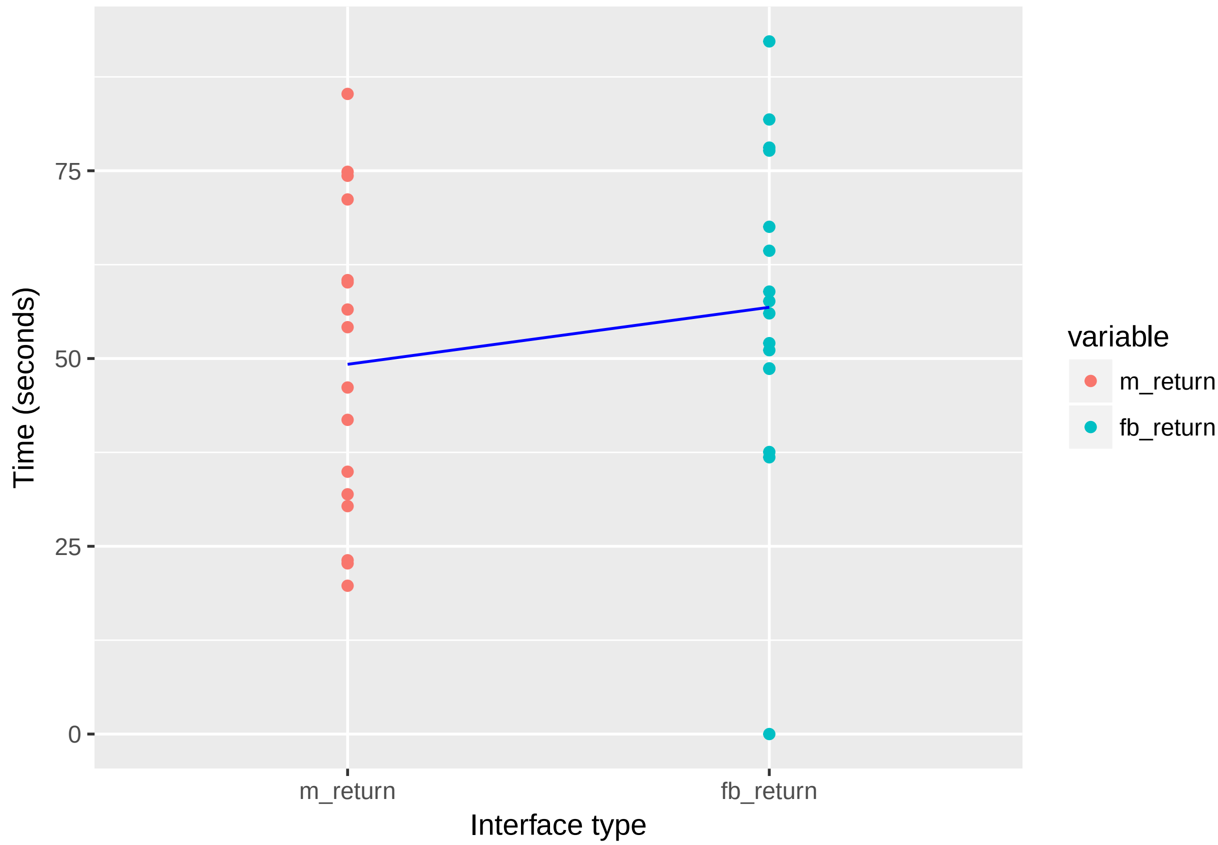

```r
ggsave("time-borrow.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
## No summary function supplied, defaulting to `mean_se()
## No summary function supplied, defaulting to `mean_se()
```

Time for return tasks

```r
ggplot(melt(dat.time[6:7]),aes(x=variable,y=value, color=variable)) +
  geom_point() +
  stat_summary(aes(y = value), fun.y = mean, colour="blue", geom="line", group=1)+
  ylab("Time (seconds)") + xlab("Interface type")
```

```
## No id variables; using all as measure variables
```



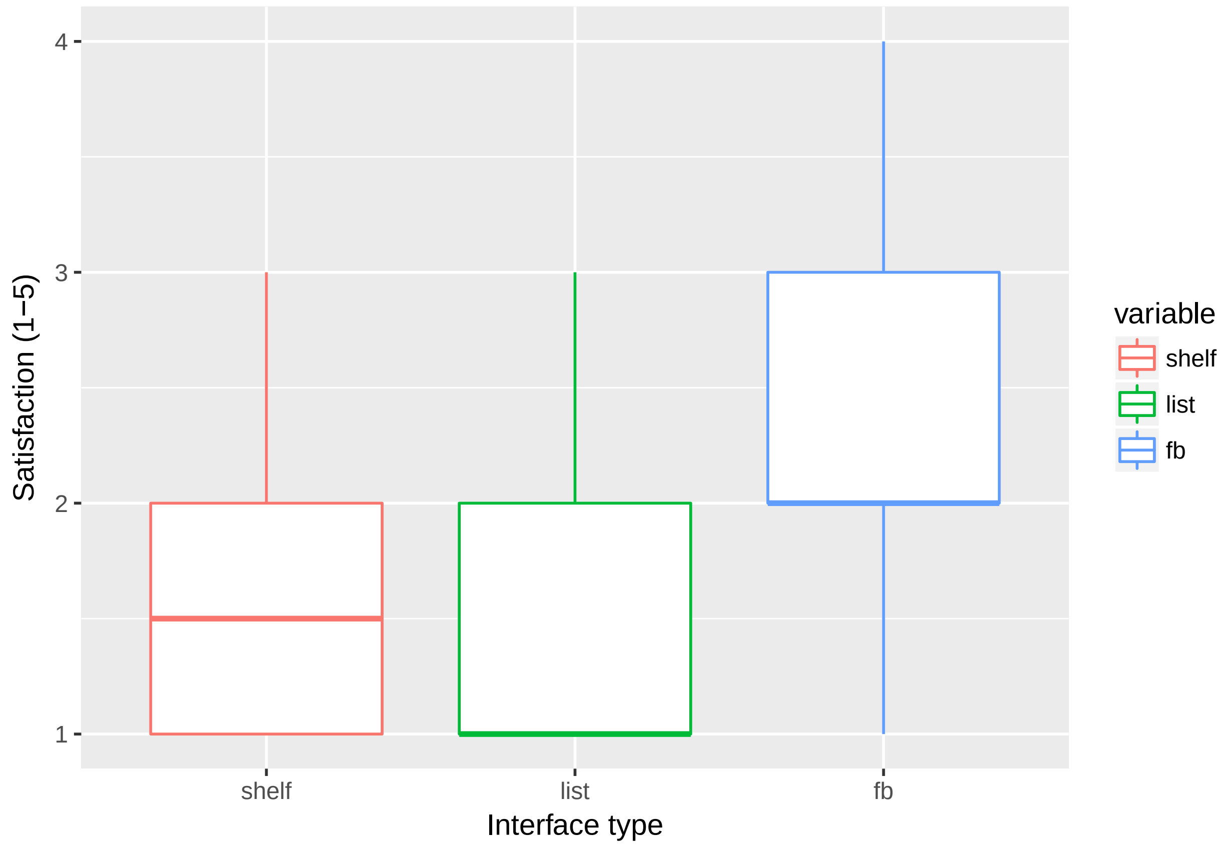

```
ggsave("time-return.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
```

Satisfaction for borrow tasks

```
ggplot(melt(dat.satisfaction[2:4]),aes(x=variable,y=value, color=variable)) +
  geom_boxplot() +
  ylab("Satisfaction (1-5)") + xlab("Interface type")
```

```
## No id variables; using all as measure variables
```



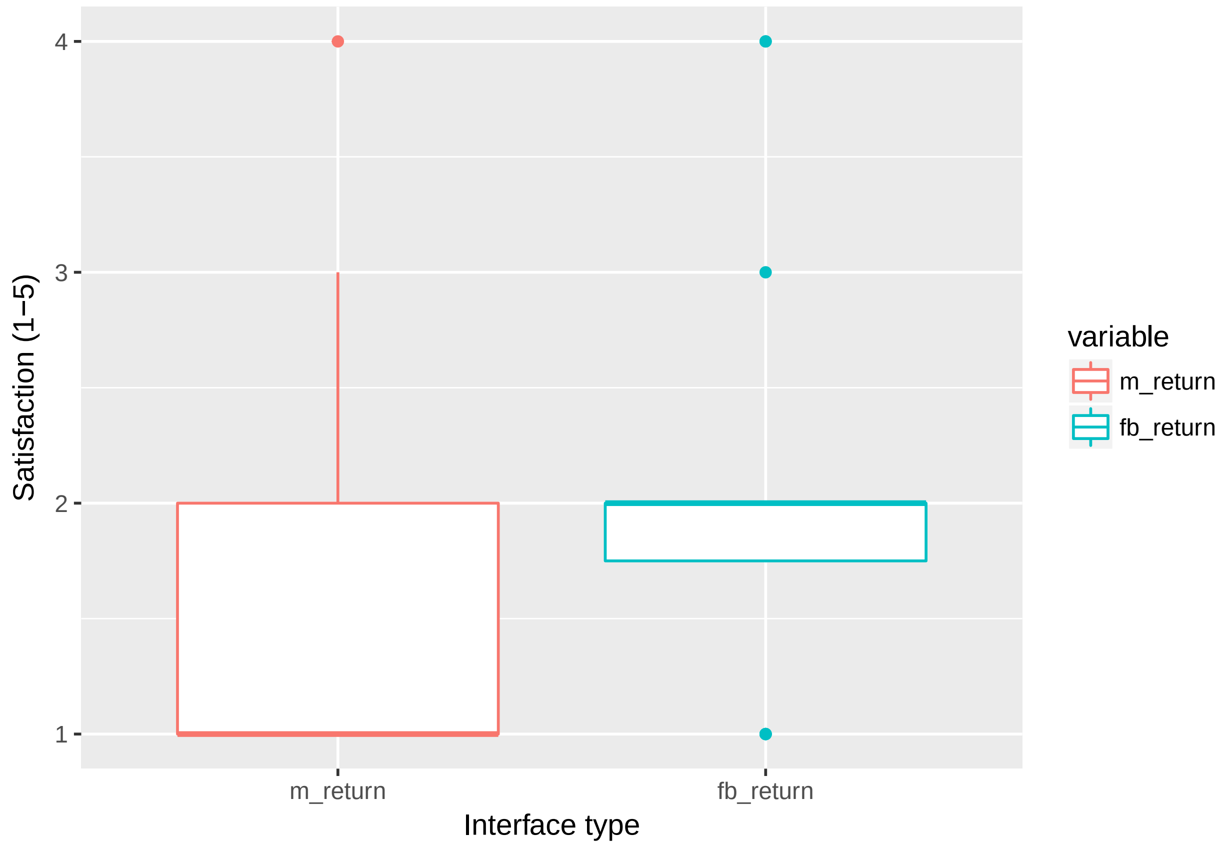

```
ggsave("sat-borrow.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
```

Satisfaction for return tasks (Facebook task depended heavily on how fast people type)

```
ggplot(melt(dat.satisfaction[5:6]),aes(x=variable,y=value, color=variable)) +
  geom_boxplot() +
  ylab("Satisfaction (1-5)") + xlab("Interface type")
```

```
## No id variables; using all as measure variables
```



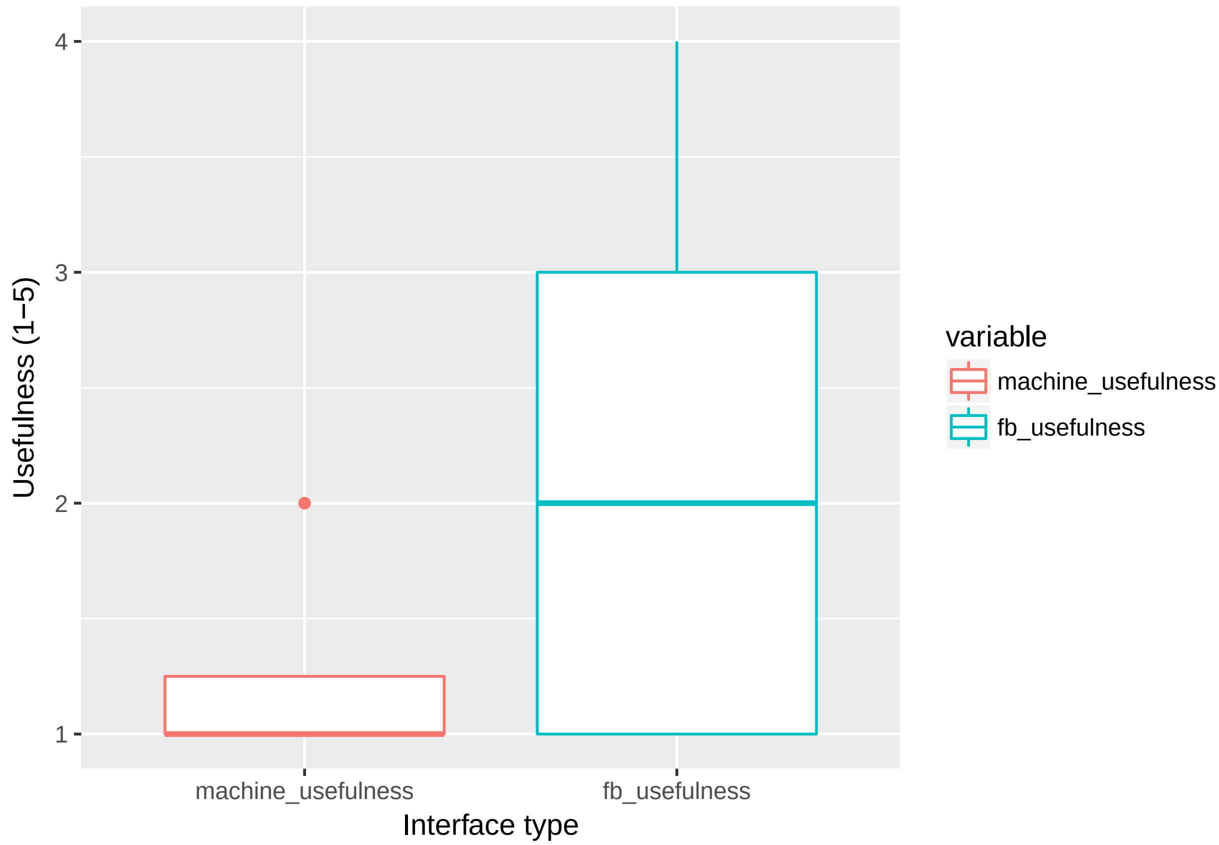

```
ggsave("sat-return.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
```

Usefulness rating

```
ggplot(melt(dat.preference[2:3]),aes(x=variable,y=value, color=variable)) +
  geom_boxplot() +
  ylab("Usefulness (1-5)") + xlab("Interface type")
```

```
## No id variables; using all as measure variables
```




```
ggsave("usefulness.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
```

Summary stats

```
kable(dat.er[3:4] %>%
  summarise_all(funs(mean, median, sd)))
```

t1e_mean	t2e_mean	t1e_median	t2e_median	t1e_sd	t2e_sd
0.4375	1.375	0	2	0.813941	1.024695

```
kable(dat.satisfaction[2:6] %>%
  summarise_all(funs(mean)))
```

shelf	list	fb	m_return	fb_return
1.625	1.375	2.1875	1.625	2.0625

```
kable(dat.satisfaction[2:6] %>%
        summarise_all(funs(median)))
```

shelf	list	fb	m_return	fb_return
1.5	1	2	1	2

```r
kable(dat.satisfaction[2:6] %>%
        summarise_all(funs(sd)))
```

shelf	list	fb	m_return	fb_return
0.7187953	0.6191392	0.8341663	0.8850612	0.9287088

```r
kable(dat.time[3:7] %>%
  summarise_all(funs(mean)))
```

shelf	list	fb	m_return	fb_return
25.95362	39.8145	82.29094	49.23006	56.8215

```r
kable(dat.time[3:7] %>%
        summarise_all(funs(median)))
```

shelf	list	fb	m_return	fb_return
20.3175	38.238	71.22	50.1585	56.8215

```r
kable(dat.time[3:7] %>%
        summarise_all(funs(sd)))
```

shelf	list	fb	m_return	fb_return
18.1288	21.71433	57.43662	20.91993	21.80287

```r
kable(dat.preference[2:3] %>%
        summarise_all(funs(mean, median)))
```

machine_usefulness_mean	fb_usefulness_mean	machine_usefulness_median	fb_usefulness_median
1.25	1.9375	1	2

To prepare time data before running mixed factorial ANOVA, run tests to determine if ANOVA assumptions hold. If data has homogenuos variance (Bartlett) and is normally distributed (Shapiro Wilk).

```r
bartlett.test(dat.time[2:5])
```

```
## Warning in FUN(X[[i]], ...): Calling var(x) on a factor x is deprecated and will become an error.
##   Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  dat.time[2:5]
## Bartlett's K-squared = 131.33, df = 3, p-value < 2.2e-16
```

Put data in the correct format

```r
dat.aov <- melt(dat.time[2:5])
```

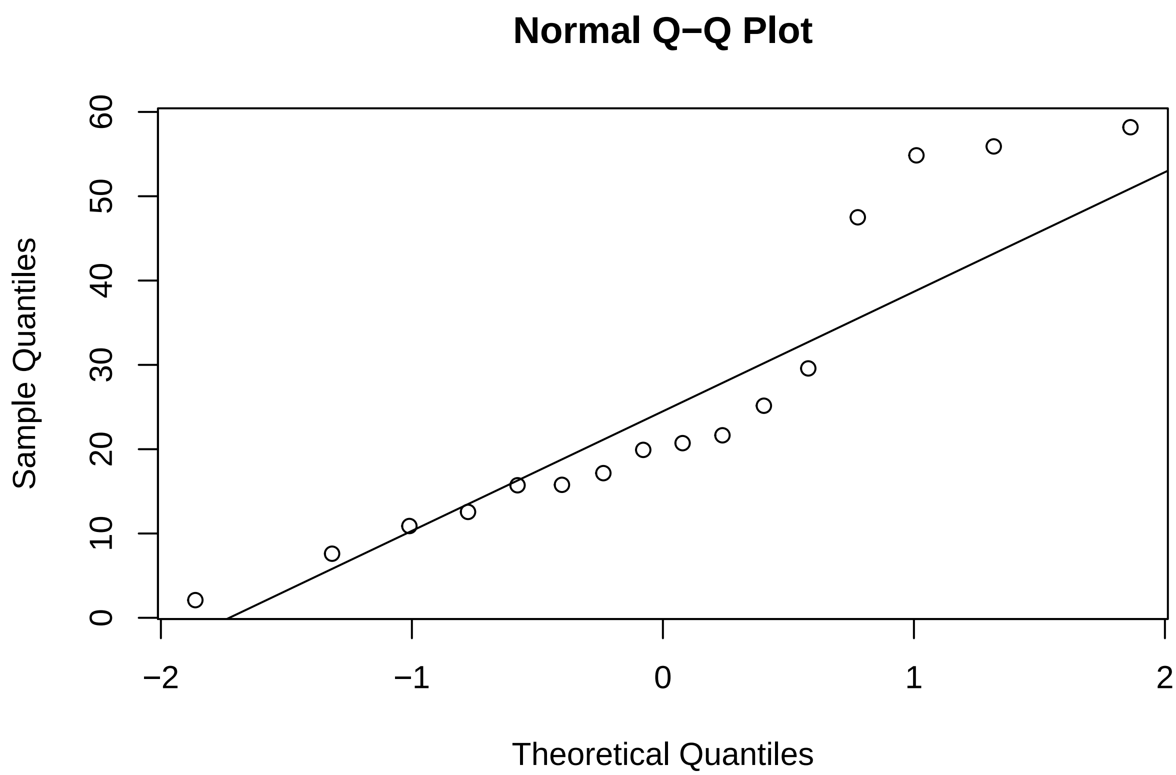
```
## Using h as id variables
```

```r
shapiro.test(dat.aov$value)
```

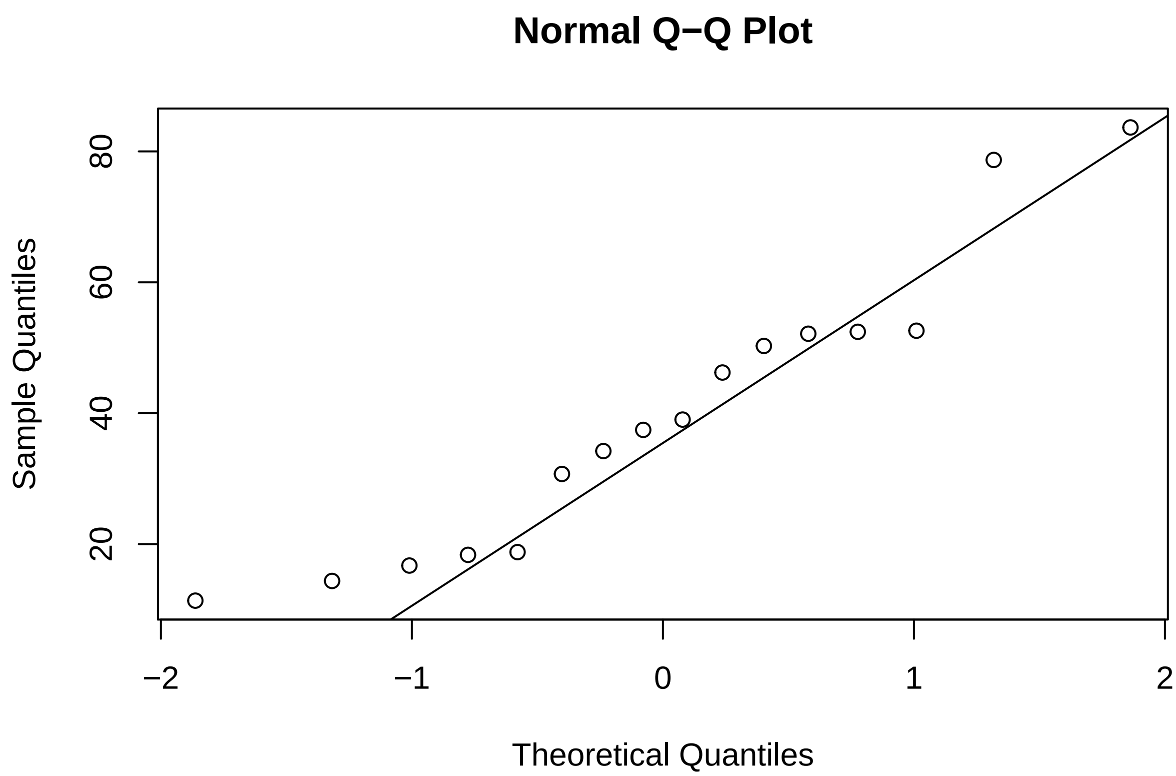
```
##
##  Shapiro-Wilk normality test
##
## data:  dat.aov$value
## W = 0.7122, p-value = 2.194e-08
```

Plot quantile-quantile to see how far data deviates from normal. Normal assumption seems to hold so we can run our ANOVA.

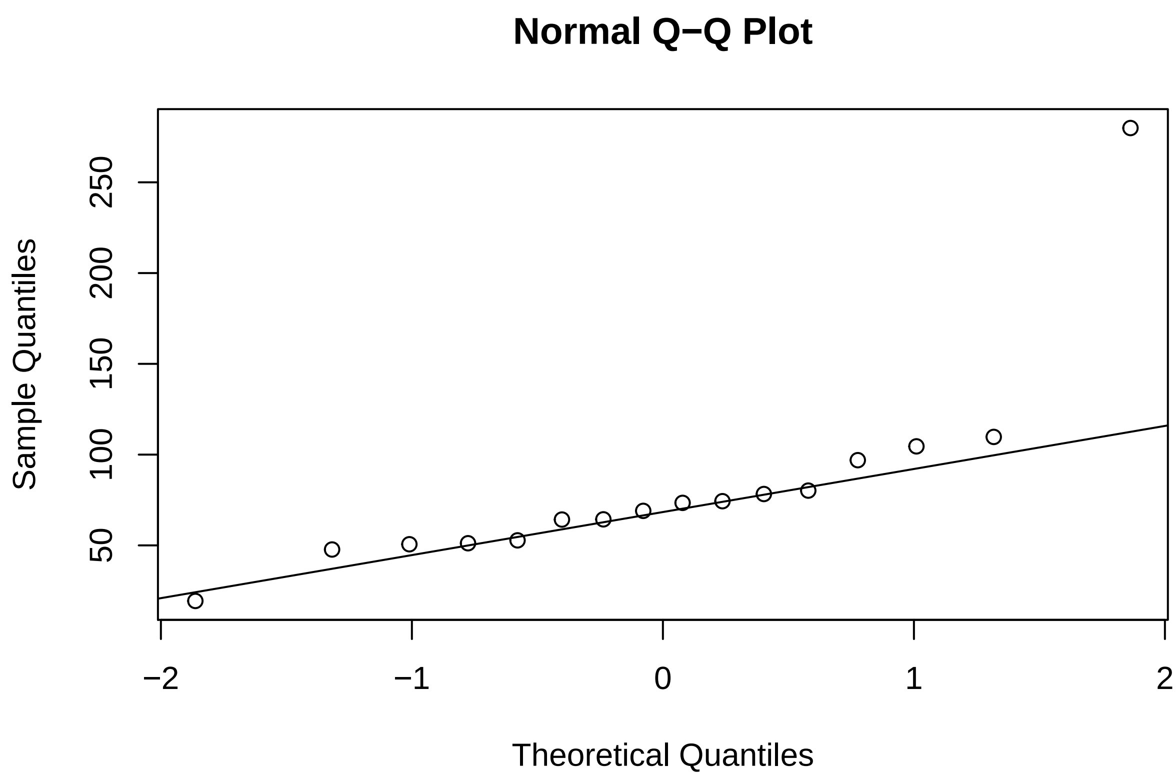
```r
qqnorm(subset(dat.aov, variable == "shelf")$value);qqline(subset(dat.aov, variable == "shelf")$value)
```




```r
qqnorm(subset(dat.aov, variable == "list")$value);qqline(subset(dat.aov, variable == "list")$value)
```




```
qqnorm(subset(dat.aov, variable == "fb")$value);qqline(subset(dat.aov, variable == "fb")$value)
```



Fit the linear model (value ~ variable * h) value is the measurement (time), variable is the UI type, and h is the home type.

```r
fit <- lm(formula = value ~ variable * h, data = dat.aov)
anova(fit)
```

```
## Analysis of Variance Table
##
## Response: value
##             Df Sum Sq Mean Sq F value    Pr(>F)
## variable     2  27575 13787.4  9.9525 0.0002897 ***
## h            1   1584  1584.3  1.1436 0.2910005
## variable:h   2   1719   859.6  0.6205 0.5425175
## Residuals   42  58183  1385.3
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This is the same as above but using the ANOVA native function of R

```r
aov.fit <- aov(formula = value ~ variable * h, data = dat.aov)
summary(aov.fit)
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## variable     2  27575   13787   9.952 0.00029 ***
## h            1   1584    1584   1.144 0.29100
## variable:h   2   1719     860   0.621 0.54252
## Residuals   42  58183    1385
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey Honest Significant Differences is a post-hoc test to determine the difference in means in terms of the UI type factor (variable).

```r
TukeyHSD(aov.fit, "variable", ordered = TRUE)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##     factor levels have been ordered
##
## Fit: aov(formula = value ~ variable * h, data = dat.aov)
##
## $variable
##                diff       lwr      upr     p adj
## list-shelf 13.86087 -18.10937 45.83112 0.5479598
## fb-shelf   56.33731  24.36707 88.30755 0.0003055
## fb-list    42.47644  10.50620 74.44668 0.0067032
```

Significant effect of interface, but no interaction effect of housing type and interface Difference between FB and shelf and FB and list is significant. Prepare data to run friedman test on satisfaction (3 factor)

```r
dat.fr <- as.matrix(dat.satisfaction[2:4])
friedman.test(dat.fr)
```

```
##
##  Friedman rank sum test
##
## data:  dat.fr
## Friedman chi-squared = 9.2558, df = 2, p-value = 0.009775
```

Significant difference detected, to see what it is we conduct Wilcoxon tests with “less” hypotheses"

```r
wilcox.test(dat.satisfaction$list, dat.satisfaction$fb, paired = T, alternative = "less")
```

```
## Warning in wilcox.test.default(dat.satisfaction$list, dat.satisfaction
## $fb, : cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.satisfaction$list, dat.satisfaction
## $fb, : cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.satisfaction$list and dat.satisfaction$fb
## V = 9, p-value = 0.008271
## alternative hypothesis: true location shift is less than 0
```

```r
wilcox.test(dat.satisfaction$shelf, dat.satisfaction$fb, paired = T, alternative = "less")
```

```
## Warning in wilcox.test.default(dat.satisfaction$shelf, dat.satisfaction
## $fb, : cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.satisfaction$shelf, dat.satisfaction
## $fb, : cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.satisfaction$shelf and dat.satisfaction$fb
## V = 14, p-value = 0.04284
## alternative hypothesis: true location shift is less than 0
```

All FB tests show significant difference from FB.

```r
wilcox.test(dat.satisfaction$list, dat.satisfaction$shelf, paired = T, alternative = "less")
```

```
## Warning in wilcox.test.default(dat.satisfaction$list, dat.satisfaction
## $shelf, : cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.satisfaction$list, dat.satisfaction
## $shelf, : cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.satisfaction$list and dat.satisfaction$shelf
## V = 7, p-value = 0.1201
## alternative hypothesis: true location shift is less than 0
```

No significant difference between list and shelf though. Test usefulness. Significant results.

```r
wilcox.test(dat.preference$machine_usefulness, dat.preference$fb_usefulness, paired = T)
```

```
## Warning in wilcox.test.default(dat.preference$machine_usefulness,
## dat.preference$fb_usefulness, : cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.preference$machine_usefulness,
## dat.preference$fb_usefulness, : cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.preference$machine_usefulness and dat.preference$fb_usefulness
```

```
## V = 3.5, p-value = 0.02355
## alternative hypothesis: true location shift is not equal to 0
```

Alternative hypothesis is machine usefulness is less (better) than fb usefulness

```r
wilcox.test(dat.preference$machine_usefulness, dat.preference$fb_usefulness, paired = T, alternative =
```

```
## Warning in wilcox.test.default(dat.preference$machine_usefulness,
## dat.preference$fb_usefulness, : cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.preference$machine_usefulness,
## dat.preference$fb_usefulness, : cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.preference$machine_usefulness and dat.preference$fb_usefulness
## V = 3.5, p-value = 0.01178
## alternative hypothesis: true location shift is less than 0
```

Error rate is simply counts so we assume it's not normally distributed

```r
wilcox.test(dat.er$t1e, dat.er$t2e, paired = T)
```

```
## Warning in wilcox.test.default(dat.er$t1e, dat.er$t2e, paired = T): cannot
## compute exact p-value with ties

## Warning in wilcox.test.default(dat.er$t1e, dat.er$t2e, paired = T): cannot
## compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.er$t1e and dat.er$t2e
## V = 10, p-value = 0.01874
## alternative hypothesis: true location shift is not equal to 0
```

```r
wilcox.test(dat.er$t1e, dat.er$t2e, paired = T, alternative = "less")
```

```
## Warning in wilcox.test.default(dat.er$t1e, dat.er$t2e, paired = T,
## alternative = "less"): cannot compute exact p-value with ties

## Warning in wilcox.test.default(dat.er$t1e, dat.er$t2e, paired = T,
## alternative = "less"): cannot compute exact p-value with zeroes

##
##  Wilcoxon signed rank test with continuity correction
##
## data:  dat.er$t1e and dat.er$t2e
## V = 10, p-value = 0.009371
## alternative hypothesis: true location shift is less than 0
```

Instead of testing for interaction with non-parametric tests, we run tests comparing student housing for shelf with private residence for shelf, compare error, usefulness and satisfaction with wilcox

```r
wilcox.test(subset(dat.satisfaction, h == "Student residence")$shelf, subset(dat.satisfaction, h == "Pr
```

```
## Warning in wilcox.test.default(subset(dat.satisfaction, h == "Student
## residence")$shelf, : cannot compute exact p-value with ties

##
##  Wilcoxon rank sum test with continuity correction
```

```
##
## data:  subset(dat.satisfaction, h == "Student residence")$shelf and subset(dat.satisfaction, h == "P
## W = 28, p-value = 0.6854
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(subset(dat.satisfaction, h == "Student residence")$list, subset(dat.satisfaction, h == "Pri
```

```
## Warning in wilcox.test.default(subset(dat.satisfaction, h == "Student
## residence")$list, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  subset(dat.satisfaction, h == "Student residence")$list and subset(dat.satisfaction, h == "Pr
## W = 37, p-value = 0.5613
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(subset(dat.satisfaction, h == "Student residence")$fb, subset(dat.satisfaction, h == "Priva
```

```
## Warning in wilcox.test.default(subset(dat.satisfaction, h == "Student
## residence")$fb, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  subset(dat.satisfaction, h == "Student residence")$fb and subset(dat.satisfaction, h == "Priva
## W = 24.5, p-value = 0.4268
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(subset(dat.preference, h == "Student residence")$machine_usefulness, subset(dat.preference,
```

```
## Warning in wilcox.test.default(subset(dat.preference, h == "Student
## residence")$machine_usefulness, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  subset(dat.preference, h == "Student residence")$machine_usefulness and subset(dat.preference
## W = 24, p-value = 0.2946
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(subset(dat.er, h == "Student residence")$t1e, subset(dat.er, h == "Private house")$t1e)
```

```
## Warning in wilcox.test.default(subset(dat.er, h == "Student residence")
## $t1e, : cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  subset(dat.er, h == "Student residence")$t1e and subset(dat.er, h == "Private house")$t1e
## W = 33, p-value = 0.9447
## alternative hypothesis: true location shift is not equal to 0
```

No main effect of home type on error, usefulness or satisfaction. No real need to test interaction. When we asked people which one they prefer, the answers look like this:

```
kable(dat.preference[4:5])
```

shelf_vs_list	app_vs_fb
3	4

shelf_vs_list	app_vs_fb
5	5
2	5
2	4
3	4
5	5
2	3
2	1
1	1
1	1
2	5
1	1
4	4
2	5
4	5
2	5

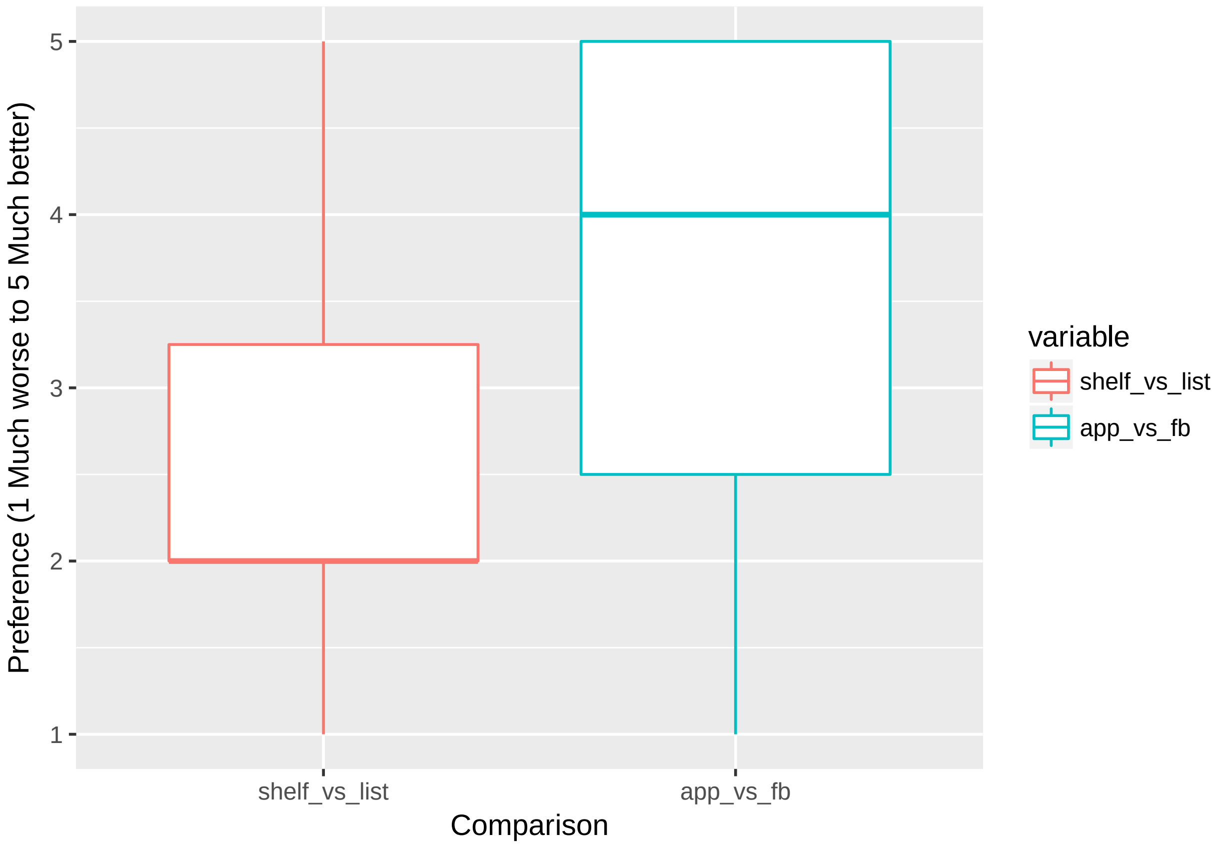
```r
kable(dat.preference[4:5] %>%
        summarise_all(funs(mean, median)))
```

shelf_vs_list_mean	app_vs_fb_mean	shelf_vs_list_median	app_vs_fb_median
2.5625	3.625	2	4

There's no need to analyze this. A plot summarizes the results.

```r
ggplot(melt(dat.preference[4:5]),aes(x=variable,y=value, color=variable)) +
  geom_boxplot() +
  ylab("Preference (1 Much worse to 5 Much better)") + xlab("Comparison")
```

```
## No id variables; using all as measure variables
```




```r
ggsave("pref-summary.png", scale = 1, path = "plots/")
```

```
## Saving 6.5 x 4.5 in image
```