Agenda

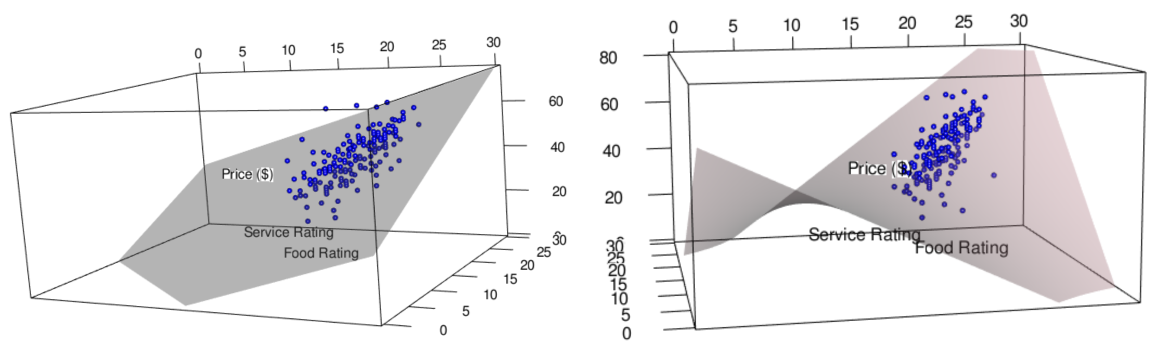
1. Interpreting nested F-tests
2. Model visualization
3. Polynomial regression

Nested F-tests Interpreting nested F-tests.

```
bloodp <- read.csv("http://www.math.smith.edu/~bbaumer/mth247/labs/bloodpress.csv")
mfull <- lm(BP ~ ., data=bloodp)
m1 <- lm(BP ~ Weight, data=bloodp)
m2 <- lm(BP ~ Weight +  Age, data=bloodp)
m3 <- lm(BP ~ Weight +  Age + Dur + Stress, data=bloodp)

# Add the models in ascending order of complexity.
anova(m1, m2, m3, mfull)

## Analysis of Variance Table
##
## Model 1: BP ~ Weight
## Model 2: BP ~ Weight + Age
## Model 3: BP ~ Weight + Age + Dur + Stress
## Model 4: BP ~ Age + Weight + BSA + Dur + Pulse + Stress
##   Res.Df    RSS Df Sum of Sq        F    Pr(>F)
## 1     18 54.528
## 2     17  4.824  1    49.704 299.7198 2.327e-10 ***
## 3     15  4.545  2     0.279   0.8406  0.453611
## 4     13  2.156  2     2.389   7.2037  0.007843 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

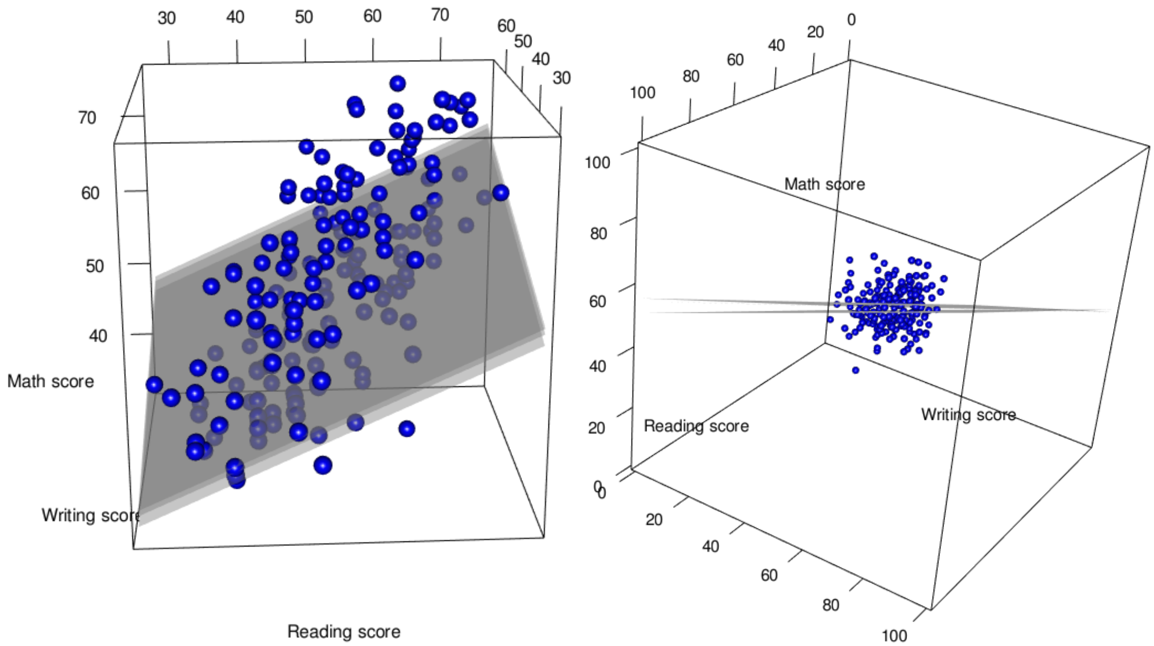
More model visualization Back to our Italian restaurant data, we have looked at these models in 3D. One was a simple plane in 3D, and the other was a warped plane, because of the interaction between two numeric variables.

```
mflat <- lm(Price ~ Food + Service, data=NYC)
mwarp <- lm(Price ~ Food + Service + Food * Service, data=NYC)
```



We were also talking about models with parallel planes and those with intersecting planes.

```
m.parallel <- lm(math~read+write+ses, data=hsb2)
m.indep <-lm(math~read+write+ses+read*ses+write*ses, data=hsb2)
```

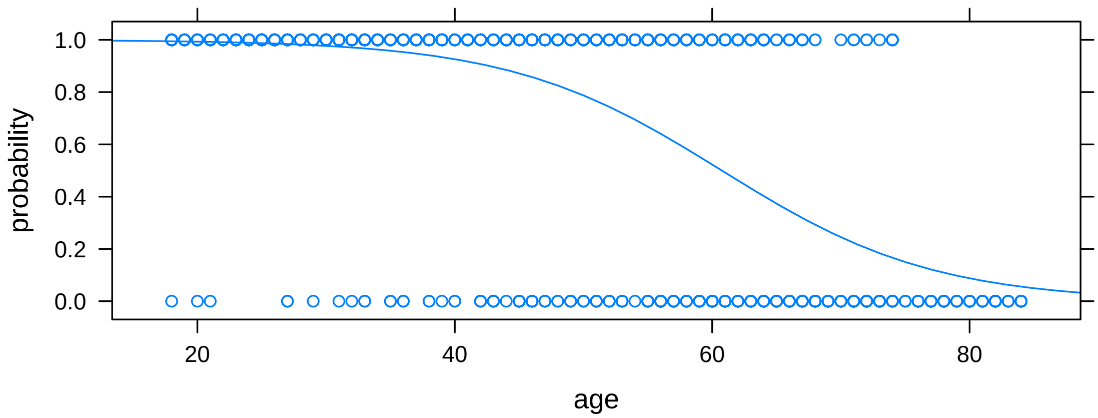


These plots have different shapes, depending on the way we choose to include terms in our model. Including a categorical variable can lead to parallel slopes or parallel planes, and an interaction between a categorical variable and a quantitative variable allows those lines or planes to have differnt slopes. Two quantative variables interacting leads to warped planes. But, what if a variable interacts with itself?

Almost always, we include the constant and linear terms in a model, although we might discover that they are not needed if other terms are added. The question is generally whether to include the quadratic and bilinear terms.

```
require(mosaic)
NYC <- read.csv("http://www.math.smith.edu/~bbaumer/mth241/nyc.csv")
m1 <- lm(Price~Food, data=NYC)
summary(m1)$adj.r.squared

## [1] 0.389528

mquad <- lm(Price ~ Food + I(Food^2), data=NYC)
summary(mquad)

##
## Call:
## lm(formula = Price ~ Food + I(Food^2), data = NYC)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -21.2196  -4.6185   0.2306   3.9387  27.2306
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  56.9185    53.1993   1.070    0.286
## Food         -4.3853     5.1887  -0.845    0.399
## I(Food^2)     0.1778     0.1257   1.414    0.159
##
## Residual standard error: 7.239 on 165 degrees of freedom
```

```
## Multiple R-squared:  0.4004,Adjusted R-squared:  0.3932
## F-statistic:  55.1 on 2 and 165 DF,  p-value: < 2.2e-16

# same result, different code
# lm(Price ~ poly(Food, 2, raw=TRUE), data=NYC)
plotModel(mquad)
```



You don't want to go too crazy with polynomials, because you can end up overfitting your data.

```
## Warning in 3/4 * pi * x:  longer object length is not a multiple of shorter object
length
## Warning in cos(3/4 * pi * x) + rnorm(26, mean = 0, sd = 0.1):  longer object length
is not a multiple of shorter object length
## Error in data.frame(y = y, x = x):  arguments imply differing number of rows:  1314,
26
```

```
xyplot(y~x, data=d1, type=c("p", "r"), xlab="", ylab="")

## Error in eval(substitute(groups), data, environment(x)):  object 'd1' not found

mcube <- lm(y~poly(x, 3, raw=TRUE), data=d1)

## Error in is.data.frame(data):  object 'd1' not found

plotModel(mcube, xlab="", ylab="")

## Error in plotModel(mcube, xlab = "", ylab = ""):  object 'mcube' not found

mlots <- lm(y~poly(x, 26, raw=TRUE), data=d1)

## Error in is.data.frame(data):  object 'd1' not found

plotModel(mlots, xlab="", ylab="")

## Error in plotModel(mlots, xlab = "", ylab = ""):  object 'mlots' not found

summary(mlots)$r.squared

## Error in summary(mlots):  object 'mlots' not found
```