Odds Ratios

- The ratio of the probability of choosing one outcome category over the probability of choosing the baseline category is often referred as **relative risk**
- It is also sometimes referred as **odds**.

Multinomial Logistic Regression with R

- The relative risk is the (right-hand side) linear equation exponentiated, leading to the fact that the exponentiated regression coefficients are relative risk ratios for a unit change in the predictor variable.
- We can exponentiate the coefficients from our model to see these odds ratios (next slide).

Multinomial Logistic Regression with R

Extract the coefficients from the model then and exponentiate

```
exp(coef(test))

          (Intercept) sesmiddle seshigh  write
 general        17.33    0.5867  0.3126 0.9437
 vocation      184.61    1.3383  0.3743 0.8926
```

Multinomial Logistic Regression with R

- The relative risk ratio for a one-unit increase in the variable **write** is 0.9437 for being in general program vs. academic program.
- The relative risk ratio switching from **ses** $= 1$ to 3 is 0.3126 for being in general program vs. academic program.

Multinomial Regression with R

- You can also use predicted probabilities to help you understand the model.
- You can calculate predicted probabilities for each of our outcome levels using the `fitted` function.
- We can start by generating the predicted probabilities for the observations in our dataset and viewing the first few rows

Multinomial Regression with R

```
head(pp <- fitted(test))

  academic general vocation
1   0.1483  0.3382   0.5135
2   0.1202  0.1806   0.6992
3   0.4187  0.2368   0.3445
4   0.1727  0.3508   0.4765
5   0.1001  0.1689   0.7309
6   0.3534  0.2378   0.4088
```

Multinomial Regression with R

Prediction

- Suppose we want to examine the changes in predicted probability associated with one of our two variables, we can create small datasets varying one variable while holding the other constant.
- We will first do this holding **write** at its mean and examining the predicted probabilities for each level of **ses**.
- *(i.e. Three Cases to predict for)*

Multinomial Logistic Regression with R

```
dses <- data.frame(ses = c("low", "middle", "h
                   write = mean(ml$write))
predict(test, newdata = dses, "probs")

   academic general vocation
1    0.4397  0.3582   0.2021
2    0.4777  0.2283   0.2939
3    0.7009  0.1785   0.1206
```

Multinomial Logistic Regression with R

- Another way to understand the model using the predicted probabilities is to look at the averaged predicted probabilities for different values of the continuous predictor variable **write** within each level of **ses**.

Multinomial Logistic Regression with R

Store the predicted probabilities for each value of ses and write

```
dwrite <- data.frame(
  ses = rep(c("low", "middle", "high"), each = 41),
  write = rep(c(30:70), 3))
```

```
pp.write <- cbind(dwrite,
     predict(test, newdata = dwrite,
     type = "probs", se = TRUE))
```

Multinomial Logistic Regression with R

Calculate the mean probabilities within each level of ses

```
by(pp.write[, 3:5], pp.write$ses, colMeans)

 pp.write$ses: high
 academic  general vocation
   0.6164   0.1808   0.2028
 ------------------------------------
 pp.write$ses: low
 academic  general vocation
   0.3973   0.3278   0.2749
 ------------------------------------
 pp.write$ses: middle
 academic  general vocation
   0.4256   0.2011   0.3733
```

Multinomial Regression with R

- A couple of plots can convey a good deal amount of information.
- Using the predictions we generated for the `pp.write` object above, we can plot the predicted probabilities against the writing score by the level of **ses** for different levels of the outcome variable.

Multinomial Logistic Regression with R

remark: melt data set to long for ggplot2

```
lpp <- melt(pp.write, id.vars = c("ses", "write"),
            value.name = "probability")

head(lpp)  # view first few rows

  ses write variable probability
1 low    30 academic     0.09844
2 low    31 academic     0.10717
3 low    32 academic     0.11650
4 low    33 academic     0.12646
5 low    34 academic     0.13705
6 low    35 academic     0.14828
```

Multinomial Regression with R

plot predicted probabilities across write values for each level of ses facetted by program type

```
ggplot(lpp, aes(x = write, y = probability, co
    ., scales = "free")
```