Conjoint Analysis

Crystal

May 7, 2017

Simulate Conjoint Data

```
set.seed(12345)
resp.id <- 1:200
nques <- 16
speed <- sample(as.factor(c("40", "50", "60", "70")), size = nques,
                replace = TRUE)
height <- sample(as.factor(c("200", "300", "400")), size=nques, replace=TRUE)
const <- sample(as.factor(c("Wood", "Steel")), size= nques, replace=TRUE)
theme <- sample(as.factor(c("Dragon", "Eagle")), size=nques, replace=TRUE)
profiles.df <- data.frame(speed, height, const, theme)

# converts the list of design attributes into coded variables
profiles.model <- model.matrix(~ speed + height + const + theme, data = profiles.df)

# draw unique preference weights
weights <- mvrnorm(length(resp.id),
                   mu = c(-3, 0.5, 1, 3, 2, 1, 0, -0.5),
                   Sigma = diag(c(0.2, 0.1, 0.1, 0.1, 0.2, 0.3, 1, 1)))

# Simulate Conjoint Data
conjoint.df <- NULL
for(i in seq_along(resp.id)) {
  utility <- profiles.model %*% weights[i, ] + rnorm(16) # add noise in by rnorm()
  rating <- as.numeric(cut(utility, 10))  # put on a 10-point scale
  conjoint.resp <- cbind(resp.id = rep(i, nques), rating, profiles.df)
  conjoint.df <- rbind(conjoint.df,conjoint.resp)
}
```

Regular Linear Modelling

```
summary(conjoint.df)
```

```
##     resp.id          rating        speed    height      const
##  Min.   :  1.00   Min.   : 1.000   40:800   200: 800   Steel:1400
##  1st Qu.: 50.75   1st Qu.: 3.000   50:800   300:1400   Wood :1800
##  Median :100.50   Median : 5.000   60:800   400:1000
##  Mean   :100.50   Mean   : 5.238   70:800
##  3rd Qu.:150.25   3rd Qu.: 7.000
##  Max.   :200.00   Max.   :10.000
##     theme
##  Dragon:1600
```

```
##  Eagle :1600
##
##
##
##
```

```r
by(conjoint.df$rating, conjoint.df$height, mean)
```

```
## conjoint.df$height: 200
## [1] 3.45625
## --------------------------------------------------------
## conjoint.df$height: 300
## [1] 6.595714
## --------------------------------------------------------
## conjoint.df$height: 400
## [1] 4.764
```

```r
ride.lm <- lm(rating ~ speed + height + const + theme, data = conjoint.df)
summary(ride.lm)
```

```
##
## Call:
## lm(formula = rating ~ speed + height + const + theme, data = conjoint.df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.3349 -1.2061 -0.0774  1.3776  6.0629
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.19723    0.10210  21.520  < 2e-16 ***
## speed50      0.67191    0.12183   5.515 3.76e-08 ***
## speed60      1.36611    0.11881  11.498  < 2e-16 ***
## speed70      4.06970    0.13288  30.626  < 2e-16 ***
## height300    2.83188    0.10167  27.853  < 2e-16 ***
## height400    1.42517    0.09393  15.173  < 2e-16 ***
## constWood    0.13715    0.08106   1.692   0.0907 .
## themeEagle  -0.49436    0.09829  -5.030 5.19e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.899 on 3192 degrees of freedom
## Multiple R-squared:  0.5176, Adjusted R-squared:  0.5165
## F-statistic: 489.2 on 7 and 3192 DF,  p-value: < 2.2e-16
```

Fixed effects that are estimated at the sample level. The highest rated roller coaster on average would have a top speed of 70 mph, a height of 300 ft, steel construction, and the dragon theme. BUT, The coefficients are estimated on the basis of designs that mostly combine both desirable and undesirable attributes, and are not as reliable at the extremes of preference. Additionally, it could happen that few people prefer that exact combination even though the individual features are each best on average.

Hierarchical Linear Model

HLM estimates both the overall average preference level and individual preferences within the group.

```
ride.hlm1 <- lmer(rating ~ speed + height + const + theme +
                    (1 | resp.id), data = conjoint.df)
summary(ride.hlm1)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: rating ~ speed + height + const + theme + (1 | resp.id)
##    Data: conjoint.df
##
## REML criterion at convergence: 13105.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2639 -0.6826 -0.0114  0.6591  3.0044
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  resp.id  (Intercept) 0.3002   0.5479
##  Residual             3.3061   1.8183
## Number of obs: 3200, groups:  resp.id, 200
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  2.19723    0.10517   20.89
## speed50      0.67191    0.11666    5.76
## speed60      1.36611    0.11377   12.01
## speed70      4.06970    0.12725   31.98
## height300    2.83188    0.09736   29.09
## height400    1.42517    0.08995   15.84
## constWood    0.13715    0.07762    1.77
## themeEagle  -0.49436    0.09412   -5.25
##
## Correlation of Fixed Effects:
##            (Intr) sped50 sped60 sped70 hgh300 hgh400 cnstWd
## speed50    -0.112
## speed60    -0.076  0.650
## speed70    -0.008  0.691  0.702
## height300  -0.661 -0.267 -0.332 -0.388
## height400  -0.523 -0.233 -0.151 -0.177  0.601
## constWood  -0.395 -0.278 -0.450 -0.451  0.378  0.164
## themeEagle -0.325 -0.590 -0.503 -0.635  0.491  0.229  0.262
```

For the intercept, that is signified as simply "1"; the grouping variable, for which a random effect will be estimated for each unique group. Syntax: predictors | group, specify the random effect and grouping variable with syntax using a vertical bar "|". In present case, it is interesting to know the randome effetc("1") of intercept on each individaul level.

```
fixef(ride.hlm1)
```

```
## (Intercept)     speed50     speed60     speed70   height300   height400
```

```
##   2.1972301   0.6719108   1.3661055   4.0696963   2.8318778   1.4251718
##   constWood  themeEagle
##   0.1371520  -0.4943631
```

It extracts fixed effects at the population level.

```r
ranef(ride.hlm1)$resp.id
```

```
##      (Intercept)
## 1    0.191936798
## 2    0.414043026
## 3   -0.252275657
## 4   -0.548417293
## 5    0.265972207
## 6    0.043865980
## 7    0.377025321
## 8   -0.067187134
## 9   -0.548417293
## 10   0.451060730
## 11   0.228954503
## 12  -0.215257952
## 13   0.191936798
## 14  -0.178240247
## 15  -0.030169429
## 16  -0.252275657
## 17   0.117901389
## 18  -0.400346475
## 19   0.006848275
## 20  -0.104204838
## 21  -0.400346475
## 22  -0.252275657
## 23   0.191936798
## 24  -0.400346475
## 25   0.302989912
## 26  -0.363328770
## 27  -0.622452702
## 28   0.858255480
## 29   0.599131548
## 30  -0.585434998
## 31   0.858255480
## 32  -0.104204838
## 33  -0.548417293
## 34  -0.141222543
## 35   0.747202367
## 36  -0.326311066
## 37  -0.400346475
## 38   0.451060730
## 39   0.302989912
## 40   0.117901389
## 41  -0.104204838
## 42  -0.030169429
## 43   0.747202367
## 44   0.043865980
```

```
## 45  -0.696488111
## 46  -0.474381884
## 47   0.006848275
## 48   0.302989912
## 49   0.451060730
## 50   0.377025321
## 51   0.265972207
## 52   0.377025321
## 53   0.377025321
## 54   0.302989912
## 55  -0.733505816
## 56   0.265972207
## 57   0.228954503
## 58   0.302989912
## 59  -0.252275657
## 60  -0.992629748
## 61   0.043865980
## 62  -0.030169429
## 63  -0.141222543
## 64   0.228954503
## 65   0.340007616
## 66  -0.104204838
## 67  -0.215257952
## 68  -0.215257952
## 69   0.117901389
## 70   0.080883684
## 71   0.117901389
## 72  -0.622452702
## 73   0.451060730
## 74  -0.474381884
## 75  -0.585434998
## 76   0.043865980
## 77   1.080361708
## 78  -0.363328770
## 79   0.191936798
## 80   0.302989912
## 81  -0.363328770
## 82   0.969308594
## 83  -0.326311066
## 84  -0.252275657
## 85   0.080883684
## 86  -0.844558930
## 87   0.451060730
## 88   0.340007616
## 89   0.154919094
## 90   0.562113844
## 91  -0.178240247
## 92  -0.067187134
## 93  -0.326311066
## 94  -0.141222543
## 95  -0.215257952
## 96  -0.622452702
## 97  -0.104204838
## 98   0.302989912
```

```
## 99   0.302989912
## 100  0.043865980
## 101 -0.696488111
## 102 -0.215257952
## 103  0.377025321
## 104  0.562113844
## 105  0.969308594
## 106  0.747202367
## 107  0.228954503
## 108 -1.029647453
## 109  0.117901389
## 110  0.080883684
## 111 -0.918594339
## 112  0.080883684
## 113  0.488078435
## 114  0.080883684
## 115 -0.178240247
## 116  0.747202367
## 117 -0.585434998
## 118  0.043865980
## 119  0.191936798
## 120  0.673166958
## 121 -0.807541225
## 122  0.451060730
## 123 -0.548417293
## 124  0.377025321
## 125 -0.067187134
## 126  0.228954503
## 127 -0.104204838
## 128  0.636149253
## 129 -0.548417293
## 130  0.377025321
## 131 -0.178240247
## 132  0.117901389
## 133  0.340007616
## 134 -1.066665157
## 135 -0.326311066
## 136 -0.289293361
## 137 -0.067187134
## 138  0.080883684
## 139 -0.067187134
## 140 -0.067187134
## 141 -0.326311066
## 142  0.080883684
## 143  0.154919094
## 144  0.377025321
## 145  0.895273185
## 146  0.043865980
## 147  0.191936798
## 148 -0.252275657
## 149 -0.326311066
## 150 -0.437364179
## 151  0.117901389
## 152 -0.696488111
```

```
## 153  0.228954503
## 154  0.006848275
## 155  1.043344003
## 156 -0.030169429
## 157  0.265972207
## 158 -0.363328770
## 159  0.080883684
## 160 -0.511399589
## 161  0.006848275
## 162  0.117901389
## 163  0.340007616
## 164  0.228954503
## 165 -0.289293361
## 166 -0.326311066
## 167  0.599131548
## 168  0.191936798
## 169  0.117901389
## 170 -0.289293361
## 171  0.117901389
## 172 -0.400346475
## 173 -0.067187134
## 174 -0.289293361
## 175 -0.548417293
## 176 -0.326311066
## 177  0.228954503
## 178  0.488078435
## 179 -0.030169429
## 180  0.191936798
## 181 -0.585434998
## 182  0.784220071
## 183 -0.400346475
## 184 -0.141222543
## 185  0.043865980
## 186  0.340007616
## 187  0.414043026
## 188 -0.326311066
## 189 -0.030169429
## 190  0.340007616
## 191 -0.326311066
## 192 -0.289293361
## 193  0.377025321
## 194 -1.029647453
## 195 -0.289293361
## 196 -0.104204838
## 197  0.043865980
## 198  0.154919094
## 199 -0.437364179
## 200 -0.141222543
```

It extracts random effect estimates for intercept

```r
coef(ride.hlm1)$resp.id
```

```
##     (Intercept)   speed50  speed60  speed70 height300 height400 constWood
```

```
## 1      2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 2      2.611273 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 3      1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 4      1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 5      2.463202 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 6      2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 7      2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 8      2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 9      1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 10     2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 11     2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 12     1.981972 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 13     2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 14     2.018990 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 15     2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 16     1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 17     2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 18     1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 19     2.204078 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 20     2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 21     1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 22     1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 23     2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 24     1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 25     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 26     1.833901 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 27     1.574777 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 28     3.055486 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 29     2.796362 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 30     1.611795 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 31     3.055486 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 32     2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 33     1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 34     2.056008 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 35     2.944432 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 36     1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 37     1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 38     2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 39     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 40     2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 41     2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 42     2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 43     2.944432 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 44     2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 45     1.500742 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 46     1.722848 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 47     2.204078 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 48     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 49     2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 50     2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 51     2.463202 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 52     2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 53     2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 54     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
```

```
## 55     1.463724 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 56     2.463202 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 57     2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 58     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 59     1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 60     1.204600 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 61     2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 62     2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 63     2.056008 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 64     2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 65     2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 66     2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 67     1.981972 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 68     1.981972 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 69     2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 70     2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 71     2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 72     1.574777 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 73     2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 74     1.722848 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 75     1.611795 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 76     2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 77     3.277592 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 78     1.833901 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 79     2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 80     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 81     1.833901 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 82     3.166539 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 83     1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 84     1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 85     2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 86     1.352671 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 87     2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 88     2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 89     2.352149 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 90     2.759344 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 91     2.018990 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 92     2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 93     1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 94     2.056008 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 95     1.981972 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 96     1.574777 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 97     2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 98     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 99     2.500220 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 100    2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 101    1.500742 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 102    1.981972 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 103    2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 104    2.759344 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 105    3.166539 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 106    2.944432 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 107    2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 108    1.167583 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
```

```
## 109    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 110    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 111    1.278636 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 112    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 113    2.685309 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 114    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 115    2.018990 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 116    2.944432 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 117    1.611795 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 118    2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 119    2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 120    2.870397 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 121    1.389689 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 122    2.648291 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 123    1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 124    2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 125    2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 126    2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 127    2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 128    2.833379 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 129    1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 130    2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 131    2.018990 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 132    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 133    2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 134    1.130565 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 135    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 136    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 137    2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 138    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 139    2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 140    2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 141    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 142    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 143    2.352149 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 144    2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 145    3.092503 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 146    2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 147    2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 148    1.944954 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 149    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 150    1.759866 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 151    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 152    1.500742 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 153    2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 154    2.204078 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 155    3.240574 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 156    2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 157    2.463202 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 158    1.833901 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 159    2.278114 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 160    1.685831 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 161    2.204078 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 162    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
```

```
## 163    2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 164    2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 165    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 166    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 167    2.796362 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 168    2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 169    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 170    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 171    2.315132 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 172    1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 173    2.130043 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 174    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 175    1.648813 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 176    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 177    2.426185 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 178    2.685309 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 179    2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 180    2.389167 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 181    1.611795 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 182    2.981450 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 183    1.796884 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 184    2.056008 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 185    2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 186    2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 187    2.611273 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 188    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 189    2.167061 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 190    2.537238 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 191    1.870919 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 192    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 193    2.574255 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 194    1.167583 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 195    1.907937 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 196    2.093025 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 197    2.241096 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 198    2.352149 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 199    1.759866 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
## 200    2.056008 0.6719108 1.366106 4.069696  2.831878  1.425172  0.137152
##     themeEagle
## 1   -0.4943631
## 2   -0.4943631
## 3   -0.4943631
## 4   -0.4943631
## 5   -0.4943631
## 6   -0.4943631
## 7   -0.4943631
## 8   -0.4943631
## 9   -0.4943631
## 10  -0.4943631
## 11  -0.4943631
## 12  -0.4943631
## 13  -0.4943631
## 14  -0.4943631
## 15  -0.4943631
```

```
## 16  -0.4943631
## 17  -0.4943631
## 18  -0.4943631
## 19  -0.4943631
## 20  -0.4943631
## 21  -0.4943631
## 22  -0.4943631
## 23  -0.4943631
## 24  -0.4943631
## 25  -0.4943631
## 26  -0.4943631
## 27  -0.4943631
## 28  -0.4943631
## 29  -0.4943631
## 30  -0.4943631
## 31  -0.4943631
## 32  -0.4943631
## 33  -0.4943631
## 34  -0.4943631
## 35  -0.4943631
## 36  -0.4943631
## 37  -0.4943631
## 38  -0.4943631
## 39  -0.4943631
## 40  -0.4943631
## 41  -0.4943631
## 42  -0.4943631
## 43  -0.4943631
## 44  -0.4943631
## 45  -0.4943631
## 46  -0.4943631
## 47  -0.4943631
## 48  -0.4943631
## 49  -0.4943631
## 50  -0.4943631
## 51  -0.4943631
## 52  -0.4943631
## 53  -0.4943631
## 54  -0.4943631
## 55  -0.4943631
## 56  -0.4943631
## 57  -0.4943631
## 58  -0.4943631
## 59  -0.4943631
## 60  -0.4943631
## 61  -0.4943631
## 62  -0.4943631
## 63  -0.4943631
## 64  -0.4943631
## 65  -0.4943631
## 66  -0.4943631
## 67  -0.4943631
## 68  -0.4943631
## 69  -0.4943631
```

```
## 70  -0.4943631
## 71  -0.4943631
## 72  -0.4943631
## 73  -0.4943631
## 74  -0.4943631
## 75  -0.4943631
## 76  -0.4943631
## 77  -0.4943631
## 78  -0.4943631
## 79  -0.4943631
## 80  -0.4943631
## 81  -0.4943631
## 82  -0.4943631
## 83  -0.4943631
## 84  -0.4943631
## 85  -0.4943631
## 86  -0.4943631
## 87  -0.4943631
## 88  -0.4943631
## 89  -0.4943631
## 90  -0.4943631
## 91  -0.4943631
## 92  -0.4943631
## 93  -0.4943631
## 94  -0.4943631
## 95  -0.4943631
## 96  -0.4943631
## 97  -0.4943631
## 98  -0.4943631
## 99  -0.4943631
## 100 -0.4943631
## 101 -0.4943631
## 102 -0.4943631
## 103 -0.4943631
## 104 -0.4943631
## 105 -0.4943631
## 106 -0.4943631
## 107 -0.4943631
## 108 -0.4943631
## 109 -0.4943631
## 110 -0.4943631
## 111 -0.4943631
## 112 -0.4943631
## 113 -0.4943631
## 114 -0.4943631
## 115 -0.4943631
## 116 -0.4943631
## 117 -0.4943631
## 118 -0.4943631
## 119 -0.4943631
## 120 -0.4943631
## 121 -0.4943631
## 122 -0.4943631
## 123 -0.4943631
```

```
## 124 -0.4943631
## 125 -0.4943631
## 126 -0.4943631
## 127 -0.4943631
## 128 -0.4943631
## 129 -0.4943631
## 130 -0.4943631
## 131 -0.4943631
## 132 -0.4943631
## 133 -0.4943631
## 134 -0.4943631
## 135 -0.4943631
## 136 -0.4943631
## 137 -0.4943631
## 138 -0.4943631
## 139 -0.4943631
## 140 -0.4943631
## 141 -0.4943631
## 142 -0.4943631
## 143 -0.4943631
## 144 -0.4943631
## 145 -0.4943631
## 146 -0.4943631
## 147 -0.4943631
## 148 -0.4943631
## 149 -0.4943631
## 150 -0.4943631
## 151 -0.4943631
## 152 -0.4943631
## 153 -0.4943631
## 154 -0.4943631
## 155 -0.4943631
## 156 -0.4943631
## 157 -0.4943631
## 158 -0.4943631
## 159 -0.4943631
## 160 -0.4943631
## 161 -0.4943631
## 162 -0.4943631
## 163 -0.4943631
## 164 -0.4943631
## 165 -0.4943631
## 166 -0.4943631
## 167 -0.4943631
## 168 -0.4943631
## 169 -0.4943631
## 170 -0.4943631
## 171 -0.4943631
## 172 -0.4943631
## 173 -0.4943631
## 174 -0.4943631
## 175 -0.4943631
## 176 -0.4943631
## 177 -0.4943631
```

```
## 178 -0.4943631
## 179 -0.4943631
## 180 -0.4943631
## 181 -0.4943631
## 182 -0.4943631
## 183 -0.4943631
## 184 -0.4943631
## 185 -0.4943631
## 186 -0.4943631
## 187 -0.4943631
## 188 -0.4943631
## 189 -0.4943631
## 190 -0.4943631
## 191 -0.4943631
## 192 -0.4943631
## 193 -0.4943631
## 194 -0.4943631
## 195 -0.4943631
## 196 -0.4943631
## 197 -0.4943631
## 198 -0.4943631
## 199 -0.4943631
## 200 -0.4943631
```

The complete effect for each respondent comprises the overall fixed effects that apply to everyone + the individually varying random effects.

[Complete]Hierarchical Linear Model

It estimates a random effect parameter for every coefficient of interest for every respondent.

```r
ride.hlm2 <- lmer(rating ~ speed + height + const + theme +
                    (speed + height + const + theme | resp.id),
                  data = conjoint.df,
                  control = lmerControl(optCtrl = list(maxfun = 100000)))
summary(ride.hlm2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## rating ~ speed + height + const + theme + (speed + height + const +
##     theme | resp.id)
##    Data: conjoint.df
## Control: lmerControl(optCtrl = list(maxfun = 1e+05))
##
## REML criterion at convergence: 12523.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.97883 -0.59155 -0.01661  0.58139  3.07790
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
```

```
##  resp.id  (Intercept) 0.9098   0.9538
##           speed50     0.3000   0.5477    0.11
##           speed60     0.3699   0.6082    0.01  0.45
##           speed70     0.4052   0.6365   -0.21  0.48  0.41
##           height300   0.4159   0.6449    0.20 -0.37 -0.33 -0.94
##           height400   0.6779   0.8233   -0.03 -0.27 -0.21  0.01  0.07
##           constWood   1.2826   1.1325   -0.62 -0.15  0.08 -0.06 -0.15
##           themeEagle  2.0418   1.4289   -0.64 -0.10 -0.18  0.01  0.06
##  Residual             2.0222   1.4220
##
##
##
##
##
##
##
##   0.04
##   0.00  0.12
##
## Number of obs: 3200, groups:  resp.id, 200
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  2.19723    0.10196   21.55
## speed50      0.67191    0.09912    6.78
## speed60      1.36611    0.09883   13.82
## speed70      4.06970    0.10922   37.26
## height300    2.83188    0.08875   31.91
## height400    1.42517    0.09131   15.61
## constWood    0.13715    0.10049    1.36
## themeEagle  -0.49436    0.12501   -3.95
##
## Correlation of Fixed Effects:
##            (Intr) sped50 sped60 sped70 hgh300 hgh400 cnstWd
## speed50    -0.056
## speed60    -0.053  0.616
## speed70    -0.063  0.656  0.649
## height300  -0.389 -0.285 -0.331 -0.502
## height400  -0.335 -0.232 -0.163 -0.121  0.419
## constWood  -0.520 -0.201 -0.216 -0.267  0.133  0.098
## themeEagle -0.497 -0.350 -0.329 -0.336  0.273  0.105  0.169
```

Control argument increases the maxfun number of iterations to attempt convergence from 10,000 iterations (the default) to 100,000. This allows the model to converge better.