Appendix II: R code

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Initialization

```r
# Load packages
require(survey)
```

```
## Loading required package: survey
## Warning: package 'survey' was built under R version 3.4.4
## Loading required package: grid
## Loading required package: Matrix
## Loading required package: survival
##
## Attaching package: 'survey'
## The following object is masked from 'package:graphics':
##
##     dotchart
```

```r
require(sampling)
```

```
## Loading required package: sampling
## Warning: package 'sampling' was built under R version 3.4.4
##
## Attaching package: 'sampling'
## The following objects are masked from 'package:survival':
##
##     cluster, strata
```

```r
require(dplyr)
```

```
## Loading required package: dplyr
## Warning: package 'dplyr' was built under R version 3.4.3
##
## Attaching package: 'dplyr'
## The following objects are masked from 'package:stats':
##
##     filter, lag
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
require(MASS)
```

```
## Loading required package: MASS

## Warning: package 'MASS' was built under R version 3.4.4

##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select
```

```r
# Load society dataset
society <- readRDS("Understanding Society innovation pnel wave A.RDS")

# Remove unnecessary columns
society <- society[,c(1:5,8,11,12,14,53:60,62:65,76,77,81,87,89,92,94,95)]

# a_dvage is the average age over all waves.
# Inspecting the data shows that -6 gives the age during the first wave.
society$a_dvage <- as.numeric(society$a_dvage) - 6
```

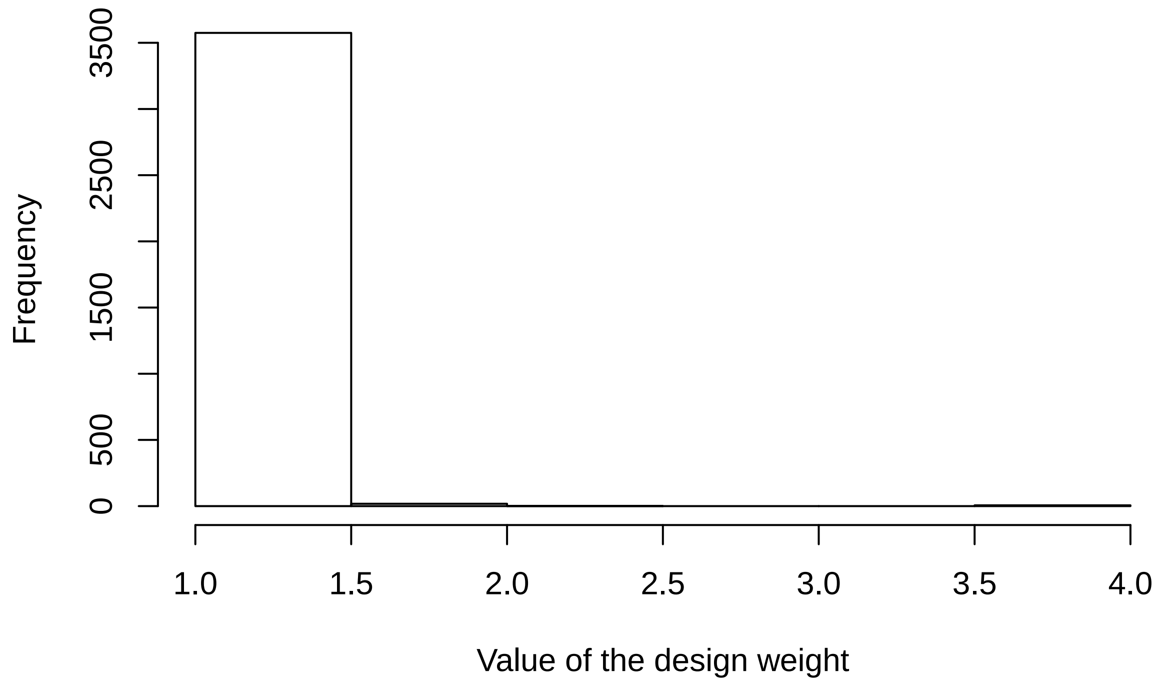
Question 2

Investigation of design weights

```r
# Calculate variance of design weight
Var <- var(society$a_psnenip_xd)
# Combine variance with other descriptive statistics
Descr <- cbind(t(summary(society$a_psnenip_xd)), Var)
# Print with up to 2 decimals
round(Descr, 2)
```

```
##      Min. 1st Qu. Median Mean 3rd Qu. Max.  Var
## [1,]    1       1      1 1.01       1    4 0.02
```

```r
# Create histogram of design weight values
hist(society$a_psnenip_xd,
     breaks = 8,
     main = NULL, #"Histogram of design weight variable 'a_psnenip_xd'",
     xlab = "Value of the design weight")
```



Question 3

```r
# Investigate levels of government office region variable
levels(society$a_gor_dv)
```

```
##  [1] "missing"                  "north east"
##  [3] "north west"               "yorkshire and the humber"
##  [5] "east midlands"            "west midlands"
##  [7] "east of england"          "london"
##  [9] "south east"               "south west"
## [11] "wales"                    "scotland"
## [13] "northern ireland"
```

```r
nrow(society[society$a_gor_dv == "missing",])
```

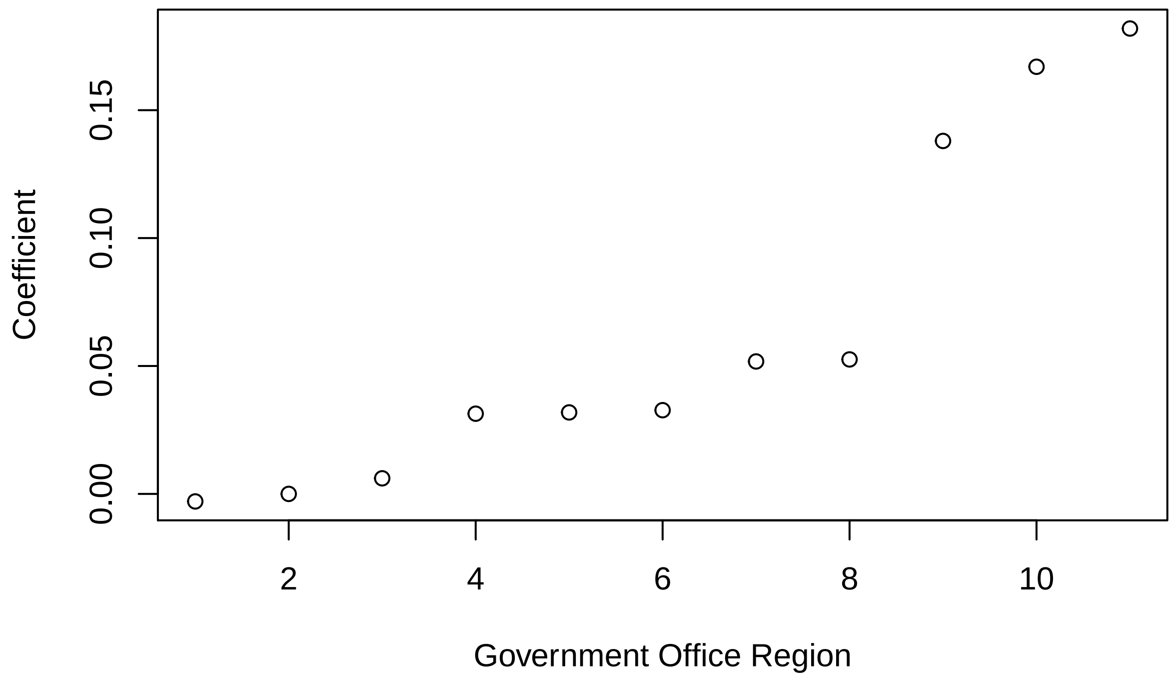
```
## [1] 0
```

```r
nrow(society[society$a_gor_dv == "northern ireland",])
```

```
## [1] 0
```

```r
# None of the value are missing or northern ireland, so those can be ignored

# Run linear regression
coeff <- with(society, lm(a_psnenip_xw ~ a_psnenip_xd + a_sex + a_dvage + a_gor_dv))

# Get coefficients of government office regions
```

```r
coeff <- coeff$coefficients
coeff.gor <- coeff[5:15]
# Add the base, which has value 0
coeff.gor[11] <- 0
names(coeff.gor)[11] <- "a_gor_dvnorth east"

# Sort and plot coefficients
plot(sort(coeff.gor), xlab = "Government Office Region", ylab = "Coefficient")
```

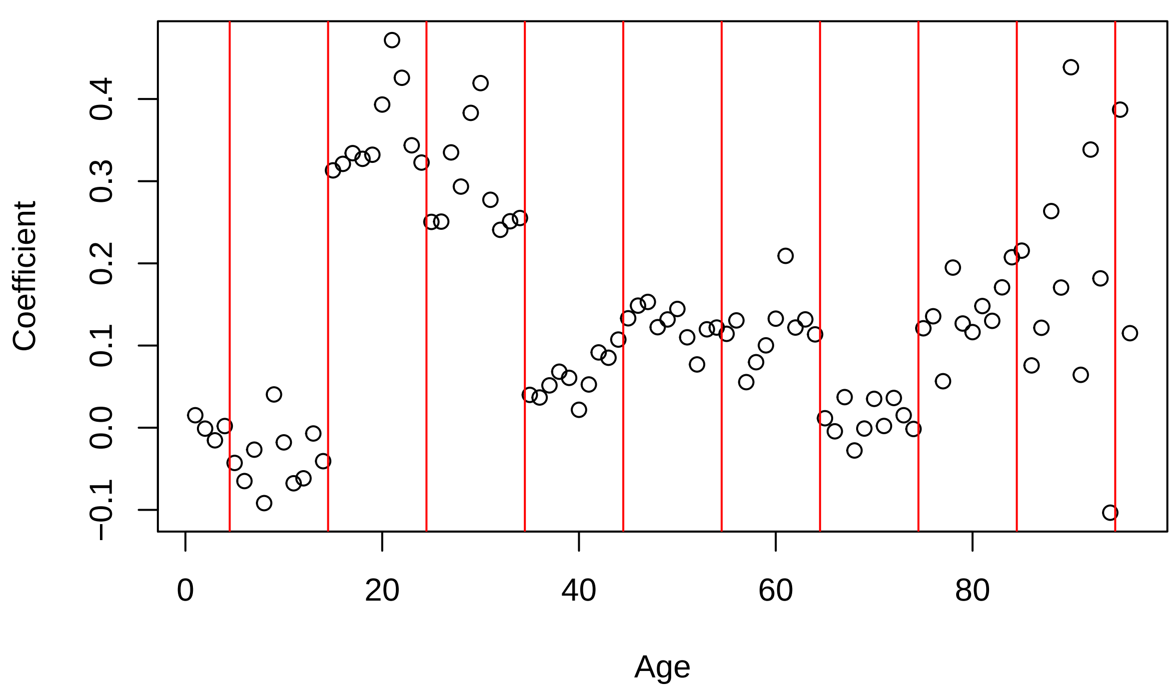



```r
# Show coefficients
coeff.gor
```

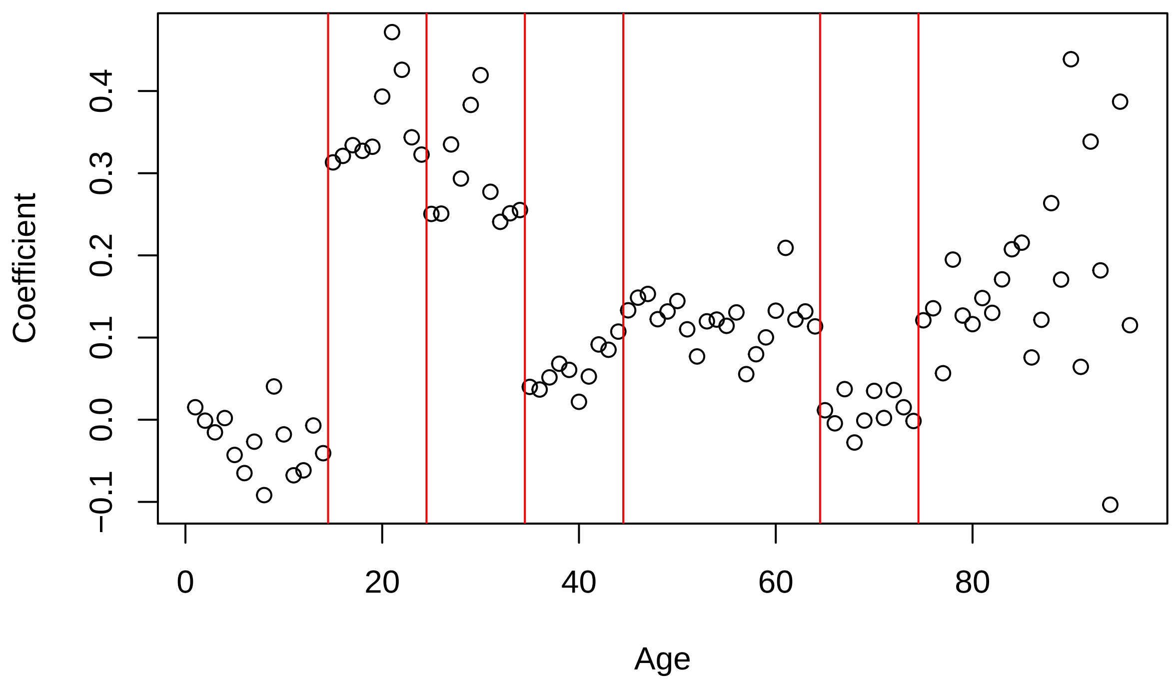
```
##              a_gor_dvnorth west a_gor_dvyorkshire and the humber
##                     0.052568228                      0.031851653
##             a_gor_dveast midlands            a_gor_dvwest midlands
##                     0.032723159                      0.137962567
##           a_gor_dveast of england                  a_gor_dvlondon
##                     0.051770584                      0.166965124
##              a_gor_dvsouth east               a_gor_dvsouth west
##                    -0.002938262                      0.006095216
##                   a_gor_dvwales                  a_gor_dvscotland
##                     0.031355723                      0.181909406
##              a_gor_dvnorth east
##                     0.000000000
```

In accordance with the data, Scotland, London and the West Midlands form one category each, with the fourth category containing all other areas.

```r
# Gather grouped region in one variable
society$gor_groups <- "England_Wales"
society$gor_groups[society$a_gor_dv=="london"] <- "London"
society$gor_groups[society$a_gor_dv == "scotland"] <- "Scotland"
society$gor_groups[society$a_gor_dv == "west midlands"] <- "West Midlands"

# Change government office region groups and age into factors
society$gor_groups <- as.factor(society$gor_groups)
society$age_fac <- as.factor(society$a_dvage)

# Rerun linear regression
coeff2 <- with(society, lm(a_psnenip_xw ~ a_psnenip_xd + a_sex + gor_groups + age_fac))

# Get coefficients
coeff2 <- coeff2$coefficients
coeff2.age <- coeff2[7:102]

# Change names of coefficients into numbers
x <- unlist(strsplit(names(coeff2.age), "age_fac"))
names(coeff2.age) <- x[x!=""]

# Plot coefficients
plot(as.numeric(names(coeff2.age)), coeff2.age, xlab="Age", ylab="Coefficient")
for (i in seq(4,104,10)+0.5){
 abline(v=i, col="red")
}
```



```r
# Plot with group changes
plot(as.numeric(names(coeff2.age)), coeff2.age, xlab="Age", ylab="Coefficient")
for (i in c(14.5,24.5,34.5,44.5,64.5,74.5)){
 abline(v=i, col="red")
}
```



In accordance with the results, age is split up in sections of 10 years, with the 0-10 and 11-20 as well as the 51-60 and 61-79 categories combined and all people of age 81 and older placed into one group.

```r
# Assign the levels
levels(society$age_fac)
```

```
##  [1] "0"  "1"  "2"  "3"  "4"  "5"  "6"  "7"  "8"  "9"  "10" "11" "12" "13"
## [15] "14" "15" "16" "17" "18" "19" "20" "21" "22" "23" "24" "25" "26" "27"
## [29] "28" "29" "30" "31" "32" "33" "34" "35" "36" "37" "38" "39" "40" "41"
## [43] "42" "43" "44" "45" "46" "47" "48" "49" "50" "51" "52" "53" "54" "55"
## [57] "56" "57" "58" "59" "60" "61" "62" "63" "64" "65" "66" "67" "68" "69"
## [71] "70" "71" "72" "73" "74" "75" "76" "77" "78" "79" "80" "81" "82" "83"
## [85] "84" "85" "86" "87" "88" "89" "90" "91" "92" "93" "94" "95" "96"
```

```r
levels(society$age_fac) <- c(rep("group0_14", 15), rep("group15_24", 10),
                              rep("group25_34", 10), rep("group35_44",10),
                              rep("group45_64", 20), rep("group65_74", 10),
                              rep("group_75", 22))

# Create table
with(society, table(age_fac,gor_groups))
```

```
##              gor_groups
## age_fac       England_Wales London Scotland West Midlands
##   group0_14             511    113       57            53
##   group15_24            286     43       21            42
##   group25_34            280     56       31            24
##   group35_44            404     72       49            49
##   group45_64            670     84       70            86
##   group65_74            245     26       34            32
##   group_75              198     27       20            17
```

```
# None of the groups has zero observations

# Run linear regression again
coeff3 <- with(society, lm(a_psnenip_xw ~ a_psnenip_xd + a_sex + gor_groups + age_fac))

#Get coefficients
coeff3 <- coeff3$coefficients
coeff3
```

```
##            (Intercept)           a_psnenip_xd             a_sexfemale
##            -0.15343264             0.98462757             -0.04870161
##       gor_groupsLondon     gor_groupsScotland gor_groupsWest Midlands
##             0.14642803             0.16871017             0.10891317
##      age_facgroup15_24      age_facgroup25_34       age_facgroup35_44
##             0.37993120             0.32321742             0.08846066
##      age_facgroup45_64      age_facgroup65_74         age_facgroup_75
##             0.14922735             0.03522097             0.17247306
```

Question 4

```
# Investigate the a_employ variable.
levels(society$a_employ[society$a_dvage > 15 & society$a_dvage < 64])
```

```
## [1] "missing"          "inapplicable"     "proxy respondent"
## [4] "refuse"           "don't know"       "yes"
## [7] "no"
```

```
# The variable a_employ has seven levels.

summary(society$a_dvage[society$a_employ=="yes"])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   16.00   32.00   42.00   41.55   51.00   96.00
```

```
summary(society$a_dvage[society$a_employ=="no"])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   16.00   39.00   63.00   56.38   73.00   96.00
```

```
# Yes and no contain people of over 21 years of age.

nrow(society[society$a_employ=="missing",])
```

```
## [1] 0
```

```
nrow(society[society$a_employ=="proxy respondent",])
```

```
## [1] 0
```

```r
# Missing and proxy respondent do not appear in the data

summary(society$a_dvage[society$a_employ=="inapplicable"])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   4.000   8.000   7.787  12.000  15.000
```

```r
# Inapplicable seems to contain all children and youths of 21 years and younger
# It cannot be assumed that none of them is employed. It can however be assumed that only
# a small part of them is employed, as children under 15 cannot be employed legally
# and most would still be going to a school or university.

nrow(society[society$a_employ=="refuse",])
```

```
## [1] 1
```

```r
nrow(society[society$a_employ=="don\'t know",])
```

```
## [1] 1
```

```r
# Both refuse and don't know contain one row. These can be treated as missing data.

# Thus, our goal is to compare the proportion of employed people (yes) of working age
# against the number of unemployed people (no, inapplicable), excluding the missing
# data (refuse, don't know)

with(society, nrow(society[a_employ=="yes" & a_dvage >64,]))
```

```
## [1] 41
```

```r
# There are people older than 64 still working, we should exclude those.
with(society, nrow(society[a_employ=="yes" & a_dvage <15,]))
```

```
## [1] 0
```

```r
# No one younger than 15 years is reported to be working, which is to be expected as it
# was not a question asked to people under 21 years of age.

# Since we wish to know the proportion of employed people of working age, we need 2 groups:
# one with employed adults and one with unemployed people and employed elderly.
society$employ_dv <- as.numeric(0)
society$employ_dv[society$a_employ=='yes' & society$a_dvage <= 65] <- 1

# Create design
# Don't remove the missing values yet, as the weights are calculated including missing values
Design <- svydesign(ids=~a_hidp, strata=~a_strata, data=society, weights=~a_psnenip_xw)
# Make a subset of non-missing values
Nonmiss <- with(Design, subset(Design, a_employ!="refuse" & a_employ!="don\'t know"))
svymean(~employ_dv, Nonmiss)
```

```
##              mean     SE
## employ_dv 0.46195 0.0098
```

```r
confint(svymean(~employ_dv, Nonmiss))
```

```
##               2.5 %    97.5 %
## employ_dv 0.4427943 0.4810984
```

```r
# 46,2% of the population is employed, with a 95% confidence interval of 44.3%-48.1%
```

Question 5b

```r
# Inspect levels of variables
levels(society$a_livesp_dv)
```

```
## [1] "No"  "Yes"
```

```r
levels(society$a_cohab_dv)
```

```
## [1] "No"  "Yes"
```

```r
levels(society$a_single_dv)
```

```
## [1] "No"  "Yes"
```

```r
levels(society$a_mastat_dv)
```

```
##  [1] "Missing"
##  [2] "Inapplicable"
##  [3] "Refusal"
##  [4] "Don't know"
##  [5] "Child under 16"
##  [6] "Single and never married/in civil partnership"
##  [7] "Married"
##  [8] "In a registered same-sex civil partnership"
##  [9] "Separated but legally married"
## [10] "Divorced"
## [11] "Widowed"
## [12] "Separated from civil partner"
## [13] "A former civil partner"
## [14] "A surviving civil partner"
## [15] "Living as couple"
```

```r
###### HOUSEHOLD SIZE PER HOUSEHOLD
# a_hidp - Household identifier
# Household size: count for each household, how many persons there are in.
# Get household size per household
count <- as.matrix(table(society$a_hidp))
summary(count)
```

```
##        V1
##  Min.   :1.000
##  1st Qu.:1.000
##  Median :2.000
##  Mean   :2.418
##  3rd Qu.:3.000
##  Max.   :8.000
```

```r
# Turn into dataframe and join to society
households <- data.frame(a_hidp=as.numeric(rownames(count)), hh_size=count)

##### NUMBER OF CHILDREN PER HOUSEHOLD
# Count the number of kids under the age of 16 using the mastat variable
for(i in households$a_hidp){
```

```
  hh <- society[society$a_hidp==i,]
  households$n_child[households$a_hidp==i]=as.numeric(table(hh$a_mastat_dv)["Child under 16"])
}

##### ANY CHILDREN IN HOUSEHOLD
# Create variable whether the household has children in it (True for households with children)
households$with_child <- households$n_child > 0

##### ANY SINGLE ADULTS IN HOUSEHOLD
# Create variable whether the person is a single adult (true) or not (false)
society$single_adult <- society$a_single_dv == "Yes" & society$a_dvage >= 16
# Create variable whether there is a single adult in the household
for(i in households$a_hidp){
  households$hasSingle[households$a_hidp==i] <- any(society$single_adult[society$a_hidp==i])
}

##### ANY COUPLES IN HOUSEHOLD
# Create variable whether the person is in a couple (true) or not (false)
society$inacouple <- society$a_livesp_dv == "Yes" | society$a_cohab_dv == "Yes"
# Create variable whether there is a couple in the household
for(i in households$a_hidp){
  households$hasCouple[households$a_hidp==i] <- any(society$inacouple[society$a_hidp==i])
}

##### HOUSEHOLD TYPE
# Create matrix containing household states
household_states <- matrix(c("Couple with children", "Couple without children",
                             "Single with children", "Single without children"), nrow=2)
# Create household info variable
households$hh_type <- ""

for (i in seq(1,nrow(households))){
  # Get right row of household state
  if (households$with_child[i]){
    child = 1
  }
  else child = 2

  # Get right column of household state
  if(households$hasCouple[i]){
    state = 1
  }
  else if(households$hasSingle[i]){
    state = 2
  }
  # Select household state and put in households$hh_type
  households$hh_type[i] <- household_states[child, state]
}

# Show how many of each category there are
table(households$hh_type)
```

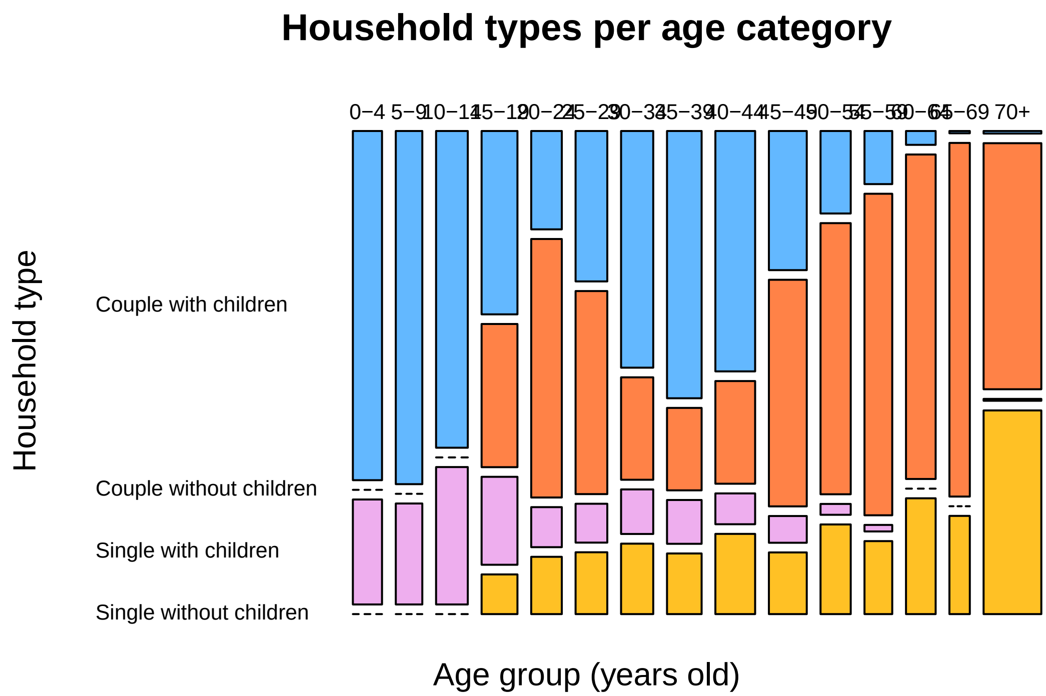
```
##
##    Couple with children Couple without children    Single with children
```

```
##                     323                        583                        112
## Single without children
##                     471
```

```r
# Join to society dataset
society <- left_join(society, households, by="a_hidp")
```

Question 5d

```r
# Create two new age variables:
# one to plot with the five-year intervals,
# one with categories to compute the chi square statistic
society$a_agegr5a_dv <- factor(society$a_agegr5_dv) #rename levels for readability
levels(society$a_agegr5a_dv) <- c("0-4", "5-9", "10-14", "15-19", "20-24", "25-29",
                                  "30-34", "35-39", "40-44", "45-49", "50-54", "55-59",
                                  "60-64", "65-69", "70+")
society$a_agegr11_dv <- factor(society$a_agegr13_dv)
# Combine levels so no NAs exist in the contingency table
levels(society$a_agegr11_dv) <- c(rep("0-17", 2), "18-19",  "20-24",  "25-29",  "30-34",
                            "35-39", "40-44",  "45-49", "50-54", "55-59",  rep("60+",2))

# Update sampling design
Design <- svydesign(ids=~pidp, strata=~a_strata, data=society, weights=~a_psnenip_xw)

# Create stacked barplot with 5 year interval variable
tab5 <- svytable(~a_agegr5a_dv + hh_type, Design) # creates a contingency table
plot(tab5, xlab = "Age group (years old)", ylab = "Household type",
     main = "Household types per age category",
     col=c("steelblue1","sienna1","plum2","goldenrod1"), las = 1, mar = c(3,4,4,2))
```




```r
# Perform chi square test to evaluate whether age and household type are independent
svychisq(~a_agegr11_dv + hh_type, design=Design, statistic = "Chisq")
```

```
##
##  Pearson's X^2: Rao & Scott adjustment
##
## data:  svychisq(~a_agegr11_dv + hh_type, design = Design, statistic = "Chisq")
## X-squared = 1763.1, df = 30, p-value < 2.2e-16
```

```r
# Remove this part??? ##########################################################################
# >>>>>>> I think this is more interesting with the 5-year variable?
tab <- svytable(~a_agegr11_dv + hh_type, Design) # creates a contingency table
# The Ntotal argument can be either a single number or a data frame whose first
# column gives the (first-stage) sampling strata and second column the population size
# in each stratum.
# In this second case the svytable command performs ???post-stratification???:
# tabulating and scaling to the population within strata and then adding up the strata.
ftable(tab)
```

```
##               hh_type Couple with children Couple without children Single with children Single withou
## a_agegr11_dv
## 0-17                            555.772730               42.555034           196.139619
## 18-19                            22.752965               39.572365            15.789405
## 20-24                            48.141271              126.500495            19.588616
## 25-29                            76.302638              103.007466            19.705917
## 30-34                           121.740711               52.679829            22.928404
## 35-39                           147.916064               45.618750            24.243592
```

```
## 40-44                        152.767689           65.253960            19.588328
## 45-49                         84.254503          137.213891            16.187806
## 50-54                         39.838316          130.933000             5.238851
## 55-59                         23.557876          142.619742             2.888893
## 60+                            9.654168          496.361554             1.721576
```

```r
summary(ftable(tab))
```

```
##        V1                 V2                V3                 V4
##  Min.   :  9.654   Min.   : 39.57   Min.   :  1.722   Min.   :  6.728
##  1st Qu.: 31.698   1st Qu.: 49.15   1st Qu.: 10.514   1st Qu.: 29.707
##  Median : 76.303   Median :103.01   Median : 19.588   Median : 33.559
##  Mean   :116.609   Mean   :125.67   Mean   : 31.275   Mean   : 53.724
##  3rd Qu.:134.828   3rd Qu.:134.07   3rd Qu.: 21.317   3rd Qu.: 40.329
##  Max.   :555.773   Max.   :496.36   Max.   :196.140   Max.   :274.959
########################################################################
```

Question 6

```r
# Summarise a_ivfio
(summary <- summary(society$a_ivfio))
```

```
##               Missing or wild                  Inapplicable
##                             0                             0
##                       Refused                    Don't know
##                             0                             0
##                Full interview               Proxy interview
##                          2399                           169
##               Telephone intvw                Lost CAPI intvw
##                             0                             0
##                       Refusal                Other non-intvw
##                           129                           101
##                         Moved Ill/away during survey period
##                             0                            14
##            Too infirm/elderly          Language difficulties
##                             6                             6
##           Unknown eligibility                Youth Interview
##                             0                           257
##                Youth: Refusal             Youth: Oth non-int
##                             0                            60
##                Child under 10           Youth non-interview
##                           459                             0
##              Moved/non-int HH             Refusal/non-int HH
##                             0                             0
##          Lang prob/non-int HH          Age, infirm/non-int HH
##                             0                             0
##           Non-cont/non-int HH         Out of scope/non-int HH
##                             0                             0
##         Institutnsd/non-int HH       Child <15 ref/non-int HH
##                             0                             0
##  Chd <15 lang prob/non-int HH     Chd <15 infirm/non-int HH
##                             0                             0
##   Chd <15 non-cont/non-int HH  Chd <15 o-o-scope/non-int HH
```

```
##                              0                              0
##     Chd <15 instit/non-int HH               TSM - no OSM/PSM
##                              0                              0
##      Prev wave adamant refusl          L-t untrace, w-drawn
##                              0                              0
##        Withdrawn before field              Other ineligible
##                              0                              0
##                Other Retiring                          Dead
##                              0                              0
```

```
summary[summary != 0]
```

```
##                Full interview               Proxy interview
##                          2399                           169
##                       Refusal                Other non-intvw
##                           129                           101
## Ill/away during survey period            Too infirm/elderly
##                            14                             6
##          Language difficulties               Youth Interview
##                             6                           257
##             Youth: Oth non-int                Child under 10
##                            60                           459
```

```
adults <- sum(society$a_ivfio == "Full interview") #the full interviews with adults
youths <- sum(society$a_ivfio ==  "Youth Interview") #the interviews with children
sum(adults, youths) #all personally completed interviews
```

```
## [1] 2656
```

```
# The nonresponse indicator is 1 for all (partial) nonresponse and 0 for full
# (youth) interviews
society$NR <- 1
society$NR[society$a_ivfio == "Youth Interview"] <- 0
society$NR[society$a_ivfio == "Full interview"] <- 0
```

Question 7

```
# Further investigate the level Language difficulties
society$a_iproxy[society$a_ivfio=="Language difficulties"]
```

```
## [1] no interview and no proxy interview - unproductive
## [2] no interview and no proxy interview - unproductive
## [3] no interview and no proxy interview - unproductive
## [4] no interview and no proxy interview - unproductive
## [5] no interview and no proxy interview - unproductive
## [6] no interview and no proxy interview - unproductive
## 7 Levels: missing inapplicable proxy respondent refuse ... no interview and no proxy interview - unp
```

```
# It's clearly a complete nonresponse

# Repeat creation of model design from Q4 so NR variable is included
Design <- svydesign(ids=~a_hidp, strata=~a_strata, data=society, weights=~a_psnenip_xw)
Nonmiss <- with(Design, subset(Design, a_employ!="refuse" & a_employ!="don\'t know"))
# Create model
I_personal <- with(Nonmiss, subset(Nonmiss, NR==0))
```

```r
# Calculate nonresponse
svymean(~employ_dv, I_personal)
```

```
##               mean     SE
## employ_dv 0.50395 0.0113
```

```r
confint(svymean(~employ_dv, I_personal))
```

```
##                2.5 %    97.5 %
## employ_dv 0.4818926 0.5260143
```

```r
# With NR: 46,2% of the population is employed, with a 95% confidence interval of 44.3%-48.1%
# Exclude NR: 50.4% of the population is employed, with a 95% confidence interval of 48.2%-52.6%

# May be caused by children of younger than 10, which were not interviewed
# (and thus nonresponders) and are not employed
summary(society$employ_dv[society$a_dvage < 10])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##       0       0       0       0       0       0
```

```r
summary(factor(society$a_ivfio[society$a_dvage < 10]))
```

```
## Child under 10
##            459
```

```r
# Create design that excludes children under the age of ten:
Nochild <- with(Nonmiss, subset(Nonmiss, a_dvage >= 10))

# Calculate nonresponse
svymean(~employ_dv, Nochild)
```

```
##               mean     SE
## employ_dv 0.52047 0.0105
```

```r
confint(svymean(~employ_dv, Nochild))
```

```
##                2.5 %    97.5 %
## employ_dv 0.4998811 0.5410506
```

```r
# Estimated proportion 52.0%, 95% CI[50.0%, 54.1%]
```

Question 8

```r
# Investigate the nonresponse
mean(society$NR) # compute proportion nonresponders
```

```
## [1] 0.2622222
```

```r
# Look at levels of household response
summary(society$a_hhresp_dv)
```

```
##        All present adults interviewed
##                                  2415
## All present adults interview or proxy
##                                   435
##          At least one adult interview
```

```
##                                 750
##                  No adult interviews
##                                   0
```

```r
# All households at least filled in the grid, so we only look into person (unit) nonresponse.
# use design weights,
#NRdesign <- svydesign(ids=~a_hidp, strata=~a_strata, data=society, weights=~ )

##### Remove and change problematic variables
# Combine races
society$a_racel_dv <- factor(society$a_racel_dv)
levels(society$a_racel_dv) <- c(
  rep("missing", 4), "UK Native", rep("White - Nonnative", 2), rep("Mixed", 4),
  rep("Asian or Asian British", 4), rep("Black/African/Carribean", 3), rep("Other",2))

# Change livewith of same-sex couples to 'yes'
society$a_livewith <- factor(society$a_livewith)
levels(society$a_livewith) <- c("inapplicable", "yes", "no", "yes")

# Combine respm16_dv and respf16_dv
society$a_resp16_dv <- "No"
society$a_resp16_dv[society$a_respf16_dv == "Yes" | society$a_respf16_dv == "Yes"] <- "Yes"



##### MODELS
# model with all predictors
fullmodel <- glm(NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv +
                   a_employ + a_dvage + a_agegr5_dv + a_agegr10_dv + a_agegr13_dv +
                   a_livesp_dv +  a_livewith + a_cohab_dv + #a_mastat_dv +
                   a_single_dv + a_depchl_dv + a_rach16_dv + a_resp16_dv +
                   a_nchild_dv + hh_type + hh_size + n_child, family = binomial, data = society)

fullmodel$coefficients
```

```
##                       (Intercept)                 a_gor_dvnorth west
##                       17.97002628                         0.52313114
##   a_gor_dvyorkshire and the humber              a_gor_dveast midlands
##                        0.25120269                        -0.23734999
##            a_gor_dvwest midlands            a_gor_dveast of england
##                        0.45737198                        -0.18578978
##                   a_gor_dvlondon                 a_gor_dvsouth east
##                        0.50407740                         0.85802664
##               a_gor_dvsouth west                     a_gor_dvwales
##                        0.44705180                         0.19028687
##                 a_gor_dvscotland                a_urban_dvrural area
##                        1.13694229                         0.27833137
##                      a_sexfemale               a_racel_dvUK Native
##                       -0.22848115                        -6.26716363
##        a_racel_dvWhite - Nonnative                   a_racel_dvMixed
##                       -5.84258984                        -5.68393705
##   a_racel_dvAsian or Asian British a_racel_dvBlack/African/Carribean
##                       -5.22295772                        -6.23981221
##                  a_racel_dvOther                    a_employrefuse
##                       -6.16469091                        17.31183400
```

```
##                 a_employdon't know                        a_employyes
##                        16.00748859                         0.73098294
##                         a_employno                            a_dvage
##                         0.54355535                         0.01819407
##            a_agegr5_dv5-9 years old          a_agegr5_dv10-14 years old
##                        -0.32410764                       -21.28686213
##          a_agegr5_dv15-19 years old          a_agegr5_dv20-24 years old
##                       -19.68951794                       -20.64166629
##          a_agegr5_dv25-29 years old          a_agegr5_dv30-34 years old
##                       -20.54152470                       -20.83854324
##          a_agegr5_dv35-39 years old          a_agegr5_dv40-44 years old
##                       -21.10052997                       -21.66147705
##          a_agegr5_dv45-49 years old          a_agegr5_dv50-54 years old
##                       -21.20734650                       -21.40061765
##          a_agegr5_dv55-59 years old          a_agegr5_dv60-64 years old
##                       -21.32896436                       -21.40859579
##          a_agegr5_dv65-69 years old             a_agegr5_dv70 years old
##                       -22.63678424                       -22.11459025
##         a_agegr10_dv10-19 years old         a_agegr10_dv20-29 years old
##                                 NA                                 NA
##         a_agegr10_dv30-39 years old         a_agegr10_dv40-49 years old
##                                 NA                                 NA
##         a_agegr10_dv50-59 years old         a_agegr10_dv60-69 years old
##                                 NA                                 NA
##       a_agegr10_dv70 years or older         a_agegr13_dv16-17 years old
##                                 NA                        -0.71607320
##         a_agegr13_dv18-19 years old         a_agegr13_dv20-24 years old
##                                 NA                                 NA
##         a_agegr13_dv25-29 years old         a_agegr13_dv30-34 years old
##                                 NA                                 NA
##         a_agegr13_dv35-39 years old         a_agegr13_dv40-44 years old
##                                 NA                                 NA
##         a_agegr13_dv45-49 years old         a_agegr13_dv50-54 years old
##                                 NA                                 NA
##         a_agegr13_dv55-59 years old         a_agegr13_dv60-64 years old
##                                 NA                                 NA
##       a_agegr13_dv65 years or older                      a_livesp_dvYes
##                                 NA                         3.40352788
##                       a_livewithyes                        a_livewithno
##                         4.97002155                         3.62437432
##                       a_cohab_dvYes                      a_single_dvYes
##                        -1.48576057                                 NA
##                       a_depchl_dvNo                      a_rach16_dvYes
##                         0.42110865                        -0.92275851
##                       a_rach16_dvNo                      a_resp16_dvYes
##                                 NA                         0.32491384
##                         a_nchild_dv     hh_typeCouple without children
##                        -0.17867657                         0.28108430
##         hh_typeSingle with children     hh_typeSingle without children
##                        -0.13038236                         0.69136344
##                             hh_size                             n_child
##                         0.26767391                         0.12904065
```

```r
# Doesn't produce errors

# Create new model without variables that constitute singularity errors:
halffullmodel <- glm(NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage +
                       a_agegr5_dv + a_agegr10_dv + a_agegr13_dv + hh_size + n_child +
                       hh_type, family = binomial, data = society)
# we delete a_racel_dv and a_employ because it is only a good predictor because it includes 'missing'

# model without any predictors
emptymodel <- nothing <- glm(NR ~ 1, family=binomial, data = society )

# backwards selection
backwards <- step(fullmodel)
```

```
## Start:  AIC=1357.31
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_employ +
##     a_dvage + a_agegr5_dv + a_agegr10_dv + a_agegr13_dv + a_livesp_dv +
##     a_livewith + a_cohab_dv + a_single_dv + a_depchl_dv + a_rach16_dv +
##     a_resp16_dv + a_nchild_dv + hh_type + hh_size + n_child
##
##
## Step:  AIC=1357.31
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_employ +
##     a_dvage + a_agegr5_dv + a_agegr10_dv + a_agegr13_dv + a_livesp_dv +
##     a_livewith + a_cohab_dv + a_depchl_dv + a_rach16_dv + a_resp16_dv +
##     a_nchild_dv + hh_type + hh_size + n_child
##
##
## Step:  AIC=1357.31
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_employ +
##     a_dvage + a_agegr5_dv + a_agegr13_dv + a_livesp_dv + a_livewith +
##     a_cohab_dv + a_depchl_dv + a_rach16_dv + a_resp16_dv + a_nchild_dv +
##     hh_type + hh_size + n_child
##
##                Df Deviance    AIC
## - a_employ      3   1254.0 1352.0
## - hh_type       3   1255.5 1353.5
## - a_dvage       1   1253.5 1355.5
## - a_cohab_dv    1   1253.6 1355.6
## - a_resp16_dv   1   1253.7 1355.7
## - a_depchl_dv   1   1253.7 1355.7
## - n_child       1   1254.0 1356.0
## - a_nchild_dv   1   1254.0 1356.0
## - a_agegr13_dv  1   1254.7 1356.7
## - a_sex         1   1255.0 1357.0
## <none>              1253.3 1357.3
## - a_urban_dv    1   1255.4 1357.4
## - a_rach16_dv   1   1256.1 1358.1
## - a_gor_dv     10   1276.6 1360.6
## - hh_size       1   1259.4 1361.4
## - a_livesp_dv   1   1272.2 1374.2
## - a_livewith    2   1279.7 1379.7
## - a_agegr5_dv   4   1586.3 1682.3
## - a_racel_dv    6   2282.9 2374.9
```

```
##
## Step:  AIC=1352.02
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
##     a_rach16_dv + a_resp16_dv + a_nchild_dv + hh_type + hh_size +
##     n_child
##
##                Df Deviance    AIC
## - hh_type       3   1256.2 1348.2
## - a_dvage       1   1254.3 1350.3
## - a_cohab_dv    1   1254.3 1350.3
## - a_resp16_dv   1   1254.4 1350.4
## - n_child       1   1254.7 1350.7
## - a_nchild_dv   1   1254.8 1350.8
## - a_depchl_dv   1   1254.9 1350.9
## - a_agegr13_dv  1   1255.3 1351.3
## - a_sex         1   1255.8 1351.8
## <none>              1254.0 1352.0
## - a_urban_dv    1   1256.1 1352.1
## - a_rach16_dv   1   1257.0 1353.0
## - a_gor_dv     10   1277.4 1355.4
## - hh_size       1   1260.0 1356.0
## - a_livesp_dv   1   1273.2 1369.2
## - a_livewith    2   1280.5 1374.5
## - a_agegr5_dv   4   1586.4 1676.4
## - a_racel_dv    6   2290.2 2376.2
##
## Step:  AIC=1348.25
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
##     a_rach16_dv + a_resp16_dv + a_nchild_dv + hh_size + n_child
##
##                Df Deviance    AIC
## - a_resp16_dv   1   1256.3 1346.3
## - a_dvage       1   1256.5 1346.5
## - n_child       1   1256.6 1346.6
## - a_cohab_dv    1   1256.6 1346.6
## - a_nchild_dv   1   1256.7 1346.7
## - a_depchl_dv   1   1257.2 1347.2
## - a_agegr13_dv  1   1257.8 1347.8
## - a_sex         1   1257.9 1347.9
## <none>              1256.2 1348.2
## - a_urban_dv    1   1258.5 1348.5
## - a_gor_dv     10   1279.6 1351.6
## - hh_size       1   1263.3 1353.3
## - a_rach16_dv   1   1264.3 1354.3
## - a_livesp_dv   1   1279.3 1369.3
## - a_livewith    2   1281.9 1369.9
## - a_agegr5_dv   4   1590.5 1674.5
## - a_racel_dv    6   2295.1 2375.1
##
## Step:  AIC=1346.3
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
```

```
##     a_rach16_dv + a_nchild_dv + hh_size + n_child
##
##                Df Deviance    AIC
## - a_dvage       1   1256.6 1344.6
## - n_child       1   1256.6 1344.6
## - a_cohab_dv    1   1256.7 1344.7
## - a_nchild_dv   1   1256.7 1344.7
## - a_depchl_dv   1   1257.2 1345.2
## - a_agegr13_dv  1   1257.8 1345.8
## - a_sex         1   1258.2 1346.2
## <none>              1256.3 1346.3
## - a_urban_dv    1   1258.5 1346.5
## - a_gor_dv     10   1279.8 1349.8
## - hh_size       1   1263.3 1351.3
## - a_rach16_dv   1   1269.4 1357.4
## - a_livesp_dv   1   1279.7 1367.7
## - a_livewith    2   1282.0 1368.0
## - a_agegr5_dv   4   1590.6 1672.6
## - a_racel_dv    6   2295.3 2373.3
##
## Step:  AIC=1344.6
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
##     a_rach16_dv + a_nchild_dv + hh_size + n_child
##
##                Df Deviance    AIC
## - n_child       1   1256.9 1342.9
## - a_cohab_dv    1   1257.0 1343.0
## - a_nchild_dv   1   1257.0 1343.0
## - a_depchl_dv   1   1257.6 1343.6
## - a_agegr13_dv  1   1258.3 1344.3
## - a_sex         1   1258.5 1344.5
## <none>              1256.6 1344.6
## - a_urban_dv    1   1258.8 1344.8
## - a_gor_dv     10   1280.0 1348.0
## - hh_size       1   1263.6 1349.6
## - a_rach16_dv   1   1269.7 1355.7
## - a_livesp_dv   1   1280.0 1366.0
## - a_livewith    2   1282.4 1366.4
## - a_agegr5_dv   4   1794.8 1874.8
## - a_racel_dv    6   2301.0 2377.0
##
## Step:  AIC=1342.93
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
##     a_rach16_dv + a_nchild_dv + hh_size
##
##                Df Deviance    AIC
## - a_nchild_dv   1   1257.1 1341.1
## - a_cohab_dv    1   1257.3 1341.3
## - a_depchl_dv   1   1257.9 1341.9
## - a_agegr13_dv  1   1258.5 1342.5
## - a_sex         1   1258.8 1342.8
## <none>              1256.9 1342.9
```

```
## - a_urban_dv    1   1259.1 1343.1
## - a_gor_dv     10   1280.8 1346.8
## - a_rach16_dv   1   1269.9 1353.9
## - hh_size       1   1271.6 1355.6
## - a_livesp_dv   1   1280.0 1364.0
## - a_livewith    2   1282.4 1364.4
## - a_agegr5_dv   4   1797.1 1875.1
## - a_racel_dv    6   2301.0 2375.0
##
## Step:  AIC=1341.09
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_cohab_dv + a_depchl_dv +
##     a_rach16_dv + hh_size
##
##                Df Deviance    AIC
## - a_cohab_dv    1   1257.5 1339.5
## - a_depchl_dv   1   1258.1 1340.1
## - a_agegr13_dv  1   1258.7 1340.7
## - a_sex         1   1258.8 1340.8
## <none>              1257.1 1341.1
## - a_urban_dv    1   1259.2 1341.2
## - a_gor_dv     10   1280.8 1344.8
## - hh_size       1   1273.8 1355.8
## - a_rach16_dv   1   1275.0 1357.0
## - a_livesp_dv   1   1280.2 1362.2
## - a_livewith    2   1283.5 1363.5
## - a_agegr5_dv   4   1797.3 1873.3
## - a_racel_dv    6   2302.9 2374.9
##
## Step:  AIC=1339.46
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_depchl_dv + a_rach16_dv +
##     hh_size
##
##                Df Deviance    AIC
## - a_depchl_dv   1   1258.4 1338.4
## - a_agegr13_dv  1   1259.1 1339.1
## - a_sex         1   1259.2 1339.2
## <none>              1257.5 1339.5
## - a_urban_dv    1   1259.6 1339.6
## - a_gor_dv     10   1281.0 1343.0
## - hh_size       1   1274.4 1354.4
## - a_rach16_dv   1   1275.3 1355.3
## - a_livesp_dv   1   1280.5 1360.5
## - a_livewith    2   1284.0 1362.0
## - a_agegr5_dv   4   1797.7 1871.7
## - a_racel_dv    6   2303.1 2373.1
##
## Step:  AIC=1338.42
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + a_livesp_dv + a_livewith + a_rach16_dv + hh_size
##
##                Df Deviance    AIC
## - a_sex         1   1260.1 1338.1
```

```
## <none>              1258.4 1338.4
## - a_urban_dv    1   1260.4 1338.4
## - a_agegr13_dv  1   1263.3 1341.3
## - a_gor_dv     10   1281.8 1341.8
## - hh_size       1   1275.1 1353.1
## - a_rach16_dv   1   1276.2 1354.2
## - a_livesp_dv   1   1281.6 1359.6
## - a_livewith    2   1285.0 1361.0
## - a_agegr5_dv   4   1798.5 1870.5
## - a_racel_dv    6   2304.6 2372.6
##
## Step:  AIC=1338.12
## NR ~ a_gor_dv + a_urban_dv + a_racel_dv + a_agegr5_dv + a_agegr13_dv +
##     a_livesp_dv + a_livewith + a_rach16_dv + hh_size
##
##                Df Deviance    AIC
## - a_urban_dv    1   1261.9 1337.9
## <none>              1260.1 1338.1
## - a_agegr13_dv  1   1264.7 1340.7
## - a_gor_dv     10   1283.8 1341.8
## - hh_size       1   1278.4 1354.4
## - a_livesp_dv   1   1283.9 1359.9
## - a_livewith    2   1286.8 1360.8
## - a_rach16_dv   1   1287.0 1363.0
## - a_agegr5_dv   4   1800.7 1870.7
## - a_racel_dv    6   2312.0 2378.0
##
## Step:  AIC=1337.89
## NR ~ a_gor_dv + a_racel_dv + a_agegr5_dv + a_agegr13_dv + a_livesp_dv +
##     a_livewith + a_rach16_dv + hh_size
##
##                Df Deviance    AIC
## <none>              1261.9 1337.9
## - a_agegr13_dv  1   1266.3 1340.3
## - a_gor_dv     10   1285.5 1341.5
## - hh_size       1   1280.7 1354.7
## - a_livesp_dv   1   1286.0 1360.0
## - a_livewith    2   1288.6 1360.6
## - a_rach16_dv   1   1288.9 1362.9
## - a_agegr5_dv   4   1801.8 1869.8
## - a_racel_dv    6   2314.1 2378.1
```

```
halfbackwards <- step(halffullmodel)
```

```
## Start:  AIC=2481.8
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr10_dv + a_agegr13_dv + hh_size + n_child + hh_type
##
##
## Step:  AIC=2481.8
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + n_child + hh_type
##
##                Df Deviance    AIC
## <none>              2411.8 2481.8
```

```
## - a_urban_dv    1   2414.6 2482.6
## - a_agegr13_dv  2   2416.9 2482.9
## - n_child       1   2416.2 2484.2
## - a_dvage       1   2417.3 2485.3
## - hh_type       3   2427.9 2491.9
## - a_gor_dv     10   2449.1 2499.1
## - a_sex         1   2452.4 2520.4
## - hh_size       1   2483.2 2551.2
## - a_agegr5_dv   4   2932.9 2994.9
```

```r
# forwards selection to compare backwards model with it.
forwards <- step(emptymodel,
scope=list(lower=formula(emptymodel),upper=formula(fullmodel)), direction="forward")
```

```
## Start:  AIC=4144.65
## NR ~ 1
##
##                Df Deviance    AIC
## + a_racel_dv    6   2013.6 2027.6
## + a_agegr5_dv  14   2619.3 2649.3
## + a_agegr10_dv  7   2634.2 2650.2
## + a_agegr13_dv 12   3291.2 3317.2
## + a_rach16_dv   2   3329.0 3335.0
## + a_dvage       1   3336.2 3340.2
## + a_employ      4   3348.4 3358.4
## + a_depchl_dv   1   3444.8 3448.8
## + hh_size       1   3752.8 3756.8
## + n_child       1   3785.1 3789.1
## + hh_type       3   3817.7 3825.7
## + a_single_dv   1   3850.8 3854.8
## + a_livesp_dv   1   3914.0 3918.0
## + a_nchild_dv   1   4080.7 4084.7
## + a_sex         1   4097.3 4101.3
## + a_gor_dv     10   4101.5 4123.5
## + a_cohab_dv    1   4123.2 4127.2
## + a_livewith    2   4122.2 4128.2
## <none>              4142.7 4144.7
## + a_resp16_dv   1   4141.5 4145.5
## + a_urban_dv    1   4142.4 4146.4
##
## Step:  AIC=2027.56
## NR ~ a_racel_dv
##
##                Df Deviance    AIC
## + a_agegr5_dv  14   1404.0 1446.0
## + a_agegr10_dv  7   1575.3 1603.3
## + a_agegr13_dv 12   1881.4 1919.4
## + a_rach16_dv   2   1908.1 1926.1
## + a_employ      4   1912.2 1934.2
## + a_depchl_dv   1   1953.6 1969.6
## + a_livewith    2   1956.9 1974.9
## + hh_type       3   1967.0 1987.0
## + a_resp16_dv   1   1994.1 2010.1
## + a_single_dv   1   1996.0 2012.0
## + a_sex         1   2000.6 2016.6
```

```
## + hh_size       1   2003.5 2019.5
## + a_livesp_dv   1   2004.0 2020.0
## + a_cohab_dv    1   2010.2 2026.2
## + a_nchild_dv   1   2010.5 2026.5
## + n_child       1   2010.9 2026.9
## <none>              2013.6 2027.6
## + a_urban_dv    1   2012.5 2028.5
## + a_dvage       1   2013.5 2029.5
## + a_gor_dv     10   2006.3 2040.3
##
## Step:  AIC=1446.03
## NR ~ a_racel_dv + a_agegr5_dv
##
##                Df Deviance    AIC
## + a_rach16_dv   2   1351.1 1397.1
## + a_agegr13_dv  2   1360.5 1406.5
## + a_employ      4   1359.9 1409.9
## + hh_size       1   1379.0 1423.0
## + hh_type       3   1385.8 1433.8
## + a_depchl_dv   1   1390.9 1434.9
## + a_livewith    2   1389.0 1435.0
## + a_resp16_dv   1   1391.9 1435.9
## + a_sex         1   1393.0 1437.0
## + a_single_dv   1   1399.7 1443.7
## + a_livesp_dv   1   1400.5 1444.5
## + a_urban_dv    1   1401.6 1445.6
## + a_dvage       1   1401.8 1445.8
## <none>              1404.0 1446.0
## + a_gor_dv     10   1384.1 1446.1
## + n_child       1   1402.5 1446.5
## + a_nchild_dv   1   1403.9 1447.9
## + a_cohab_dv    1   1404.0 1448.0
##
## Step:  AIC=1397.13
## NR ~ a_racel_dv + a_agegr5_dv + a_rach16_dv
##
##                Df Deviance    AIC
## + hh_size       1   1316.8 1364.8
## + n_child       1   1336.2 1384.2
## + hh_type       3   1333.8 1385.8
## + a_resp16_dv   1   1344.4 1392.4
## + a_nchild_dv   1   1344.8 1392.8
## + a_single_dv   1   1346.1 1394.1
## + a_livesp_dv   1   1346.3 1394.3
## + a_agegr13_dv  1   1346.6 1394.6
## + a_sex         1   1346.9 1394.9
## + a_gor_dv     10   1329.6 1395.6
## + a_livewith    2   1346.1 1396.1
## + a_depchl_dv   1   1348.1 1396.1
## <none>              1351.1 1397.1
## + a_urban_dv    1   1349.2 1397.2
## + a_dvage       1   1350.6 1398.6
## + a_cohab_dv    1   1351.1 1399.1
## + a_employ      3   1348.6 1400.6
```

```
##
## Step:  AIC=1364.81
## NR ~ a_racel_dv + a_agegr5_dv + a_rach16_dv + hh_size
##
##                Df Deviance    AIC
## + a_gor_dv     10   1293.9 1361.9
## + a_agegr13_dv  1   1312.3 1362.3
## + a_depchl_dv   1   1313.3 1363.3
## <none>              1316.8 1364.8
## + a_sex         1   1314.9 1364.9
## + a_urban_dv    1   1315.1 1365.1
## + a_livewith    2   1313.2 1365.2
## + a_single_dv   1   1315.3 1365.3
## + a_livesp_dv   1   1315.8 1365.8
## + a_dvage       1   1316.0 1366.0
## + a_resp16_dv   1   1316.5 1366.5
## + n_child       1   1316.7 1366.7
## + a_cohab_dv    1   1316.8 1366.8
## + a_nchild_dv   1   1316.8 1366.8
## + a_employ      3   1313.6 1367.6
## + hh_type       3   1314.3 1368.3
##
## Step:  AIC=1361.94
## NR ~ a_racel_dv + a_agegr5_dv + a_rach16_dv + hh_size + a_gor_dv
##
##                Df Deviance    AIC
## + a_agegr13_dv  1   1289.6 1359.6
## + a_depchl_dv   1   1290.3 1360.3
## <none>              1293.9 1361.9
## + a_urban_dv    1   1292.2 1362.2
## + a_single_dv   1   1292.3 1362.3
## + a_sex         1   1292.4 1362.4
## + a_livewith    2   1290.5 1362.5
## + a_livesp_dv   1   1293.0 1363.0
## + a_dvage       1   1293.1 1363.1
## + n_child       1   1293.5 1363.5
## + a_nchild_dv   1   1293.7 1363.7
## + a_cohab_dv    1   1293.8 1363.8
## + a_resp16_dv   1   1293.9 1363.9
## + a_employ      3   1291.0 1365.0
## + hh_type       3   1291.0 1365.0
##
## Step:  AIC=1359.56
## NR ~ a_racel_dv + a_agegr5_dv + a_rach16_dv + hh_size + a_gor_dv +
##     a_agegr13_dv
##
##               Df Deviance    AIC
## <none>             1289.6 1359.6
## + a_urban_dv   1   1287.7 1359.7
## + a_sex        1   1287.8 1359.8
## + a_livewith   2   1286.0 1360.0
## + a_single_dv  1   1288.1 1360.1
## + a_livesp_dv  1   1288.6 1360.6
## + a_depchl_dv  1   1288.8 1360.8
```

```
## + a_dvage      1   1289.2 1361.2
## + n_child      1   1289.2 1361.2
## + a_nchild_dv  1   1289.3 1361.3
## + a_cohab_dv   1   1289.5 1361.5
## + a_resp16_dv  1   1289.5 1361.5
## + hh_type      3   1286.8 1362.8
## + a_employ     3   1287.6 1363.6
```

```
halfforwards <- step(emptymodel,scope=list(lower=formula(emptymodel),
                                           upper=formula(halffullmodel)), direction="forward")
```

```
## Start:  AIC=4144.65
## NR ~ 1
##
##                Df Deviance    AIC
## + a_agegr5_dv  14   2619.3 2649.3
## + a_agegr10_dv  7   2634.2 2650.2
## + a_agegr13_dv 12   3291.2 3317.2
## + a_dvage       1   3336.2 3340.2
## + hh_size       1   3752.8 3756.8
## + n_child       1   3785.1 3789.1
## + hh_type       3   3817.7 3825.7
## + a_sex         1   4097.3 4101.3
## + a_gor_dv     10   4101.5 4123.5
## <none>              4142.7 4144.7
## + a_urban_dv    1   4142.4 4146.4
##
## Step:  AIC=2649.35
## NR ~ a_agegr5_dv
##
##                Df Deviance    AIC
## + hh_size       1   2546.5 2578.5
## + a_sex         1   2576.9 2608.9
## + hh_type       3   2590.3 2626.3
## + a_gor_dv     10   2588.5 2638.5
## + a_agegr13_dv  2   2610.6 2644.6
## + a_dvage       1   2614.2 2646.2
## + n_child       1   2616.8 2648.8
## <none>              2619.3 2649.3
## + a_urban_dv    1   2618.0 2650.0
##
## Step:  AIC=2578.51
## NR ~ a_agegr5_dv + hh_size
##
##                Df Deviance    AIC
## + a_sex         1   2505.2 2539.2
## + hh_type       3   2502.9 2540.9
## + n_child       1   2513.8 2547.8
## + a_gor_dv     10   2520.6 2572.6
## + a_agegr13_dv  2   2537.6 2573.6
## + a_dvage       1   2539.7 2573.7
## <none>              2546.5 2578.5
## + a_urban_dv    1   2545.6 2579.6
##
## Step:  AIC=2539.2
```

```
## NR ~ a_agegr5_dv + hh_size + a_sex
##
##               Df Deviance    AIC
## + hh_type      3   2465.8 2505.8
## + n_child      1   2477.9 2513.9
## + a_gor_dv    10   2475.9 2529.9
## + a_agegr13_dv  2   2495.5 2533.5
## + a_dvage      1   2497.7 2533.7
## <none>             2505.2 2539.2
## + a_urban_dv   1   2503.9 2539.9
##
## Step:  AIC=2505.85
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type
##
##               Df Deviance    AIC
## + a_gor_dv    10   2431.2 2491.2
## + a_dvage      1   2458.4 2500.4
## + a_agegr13_dv  2   2459.4 2503.4
## + n_child      1   2462.4 2504.4
## <none>             2465.8 2505.8
## + a_urban_dv   1   2464.7 2506.7
##
## Step:  AIC=2491.18
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv
##
##               Df Deviance    AIC
## + a_dvage      1   2423.9 2485.9
## + n_child      1   2426.2 2488.2
## + a_agegr13_dv  2   2424.9 2488.9
## + a_urban_dv   1   2428.5 2490.5
## <none>             2431.2 2491.2
##
## Step:  AIC=2485.88
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv + a_dvage
##
##               Df Deviance    AIC
## + n_child      1   2419.3 2483.3
## + a_agegr13_dv  2   2419.1 2485.1
## + a_urban_dv   1   2421.3 2485.3
## <none>             2423.9 2485.9
##
## Step:  AIC=2483.32
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv + a_dvage +
##     n_child
##
##               Df Deviance    AIC
## + a_agegr13_dv  2   2414.6 2482.6
## + a_urban_dv   1   2416.9 2482.9
## <none>             2419.3 2483.3
##
## Step:  AIC=2482.6
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv + a_dvage +
##     n_child + a_agegr13_dv
##
```

```
##              Df Deviance    AIC
## + a_urban_dv  1   2411.8 2481.8
## <none>             2414.6 2482.6
##
## Step:  AIC=2481.8
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv + a_dvage +
##     n_child + a_agegr13_dv + a_urban_dv
##
##        Df Deviance    AIC
## <none>      2411.8 2481.8
```

```r
# show different models:
formula(fullmodel)
```

```
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_employ +
##     a_dvage + a_agegr5_dv + a_agegr10_dv + a_agegr13_dv + a_livesp_dv +
##     a_livewith + a_cohab_dv + a_single_dv + a_depchl_dv + a_rach16_dv +
##     a_resp16_dv + a_nchild_dv + hh_type + hh_size + n_child
```

```r
formula(backwards)
```

```
## NR ~ a_gor_dv + a_racel_dv + a_agegr5_dv + a_agegr13_dv + a_livesp_dv +
##     a_livewith + a_rach16_dv + hh_size
```

```r
formula(forwards)
```

```
## NR ~ a_racel_dv + a_agegr5_dv + a_rach16_dv + hh_size + a_gor_dv +
##     a_agegr13_dv
```

```r
formula(halfforwards)
```

```
## NR ~ a_agegr5_dv + hh_size + a_sex + hh_type + a_gor_dv + a_dvage +
##     n_child + a_agegr13_dv + a_urban_dv
```

```r
formula(halffullmodel)
```

```
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr10_dv + a_agegr13_dv + hh_size + n_child + hh_type
```

```r
formula(halfbackwards)
```

```
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + n_child + hh_type
```

```r
# forwards and backwards logistic regression lead to the same model!

# dive deeper into halfbackwards since this is our model of interest
summary(halfbackwards)
```

```
##
## Call:
## glm(formula = NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage +
##     a_agegr5_dv + a_agegr13_dv + hh_size + n_child + hh_type,
##     family = binomial, data = society)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.75477  -0.56651  -0.40673   0.00008   2.71372
##
## Coefficients: (10 not defined because of singularities)
```

```
##                                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)                         16.76652  412.70674   0.041   0.9676
## a_gor_dvnorth west                   0.37806    0.32135   1.176   0.2394
## a_gor_dvyorkshire and the humber    -0.03299    0.33844  -0.097   0.9223
## a_gor_dveast midlands               -0.03274    0.35617  -0.092   0.9268
## a_gor_dvwest midlands                0.05815    0.34373   0.169   0.8657
## a_gor_dveast of england             -0.26456    0.34671  -0.763   0.4454
## a_gor_dvlondon                       0.71515    0.32162   2.224   0.0262 *
## a_gor_dvsouth east                   0.47002    0.31731   1.481   0.1385
## a_gor_dvsouth west                   0.53776    0.32338   1.663   0.0963 .
## a_gor_dvwales                        0.32822    0.37083   0.885   0.3761
## a_gor_dvscotland                     0.81341    0.33349   2.439   0.0147 *
## a_urban_dvrural area                 0.22087    0.13101   1.686   0.0918 .
## a_sexfemale                         -0.67411    0.10720  -6.288 3.21e-10 ***
## a_dvage                              0.05231    0.02205   2.373   0.0176 *
## a_agegr5_dv5-9 years old            -0.52228  588.26564  -0.001   0.9993
## a_agegr5_dv10-14 years old         -21.01672  412.70668  -0.051   0.9594
## a_agegr5_dv15-19 years old         -20.99819  412.70688  -0.051   0.9594
## a_agegr5_dv20-24 years old         -21.36426  412.70688  -0.052   0.9587
## a_agegr5_dv25-29 years old         -21.54627  412.70701  -0.052   0.9584
## a_agegr5_dv30-34 years old         -22.06177  412.70717  -0.053   0.9574
## a_agegr5_dv35-39 years old         -22.31341  412.70735  -0.054   0.9569
## a_agegr5_dv40-44 years old         -23.04011  412.70758  -0.056   0.9555
## a_agegr5_dv45-49 years old         -23.13002  412.70784  -0.056   0.9553
## a_agegr5_dv50-54 years old         -23.61020  412.70813  -0.057   0.9544
## a_agegr5_dv55-59 years old         -23.74167  412.70844  -0.058   0.9541
## a_agegr5_dv60-64 years old         -23.90215  412.70877  -0.058   0.9538
## a_agegr5_dv65-69 years old         -25.12335  412.70925  -0.061   0.9515
## a_agegr5_dv70 years old            -24.94935  412.71012  -0.060   0.9518
## a_agegr13_dv16-17 years old         -0.46717    0.48007  -0.973   0.3305
## a_agegr13_dv18-19 years old          0.32989    0.49018   0.673   0.5010
## a_agegr13_dv20-24 years old               NA         NA      NA       NA
## a_agegr13_dv25-29 years old               NA         NA      NA       NA
## a_agegr13_dv30-34 years old               NA         NA      NA       NA
## a_agegr13_dv35-39 years old               NA         NA      NA       NA
## a_agegr13_dv40-44 years old               NA         NA      NA       NA
## a_agegr13_dv45-49 years old               NA         NA      NA       NA
## a_agegr13_dv50-54 years old               NA         NA      NA       NA
## a_agegr13_dv55-59 years old               NA         NA      NA       NA
## a_agegr13_dv60-64 years old               NA         NA      NA       NA
## a_agegr13_dv65 years or older             NA         NA      NA       NA
## hh_size                              0.54251    0.06316   8.589  < 2e-16 ***
## n_child                             -0.19292    0.09192  -2.099   0.0358 *
## hh_typeCouple without children       0.77833    0.19700   3.951 7.78e-05 ***
## hh_typeSingle with children          0.10036    0.22853   0.439   0.6606
## hh_typeSingle without children       0.58360    0.25499   2.289   0.0221 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4142.7  on 3599  degrees of freedom
## Residual deviance: 2411.8  on 3565  degrees of freedom
## AIC: 2481.8
```

```
##
## Number of Fisher Scoring iterations: 17
```

```r
# evaluate backwards model compared with backwards regression/full model
anova(halfbackwards, emptymodel, test = "Chisq")  # backwards model does a better job at prediction tha
```

```
## Analysis of Deviance Table
##
## Model 1: NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + n_child + hh_type
## Model 2: NR ~ 1
##   Resid. Df Resid. Dev  Df Deviance  Pr(>Chi)
## 1      3565     2411.8
## 2      3599     4142.7 -34  -1730.8 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(halfbackwards, halffullmodel, test = "Chisq") # backwards model does an equally good job at predi
```

```
## Analysis of Deviance Table
##
## Model 1: NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + n_child + hh_type
## Model 2: NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage + a_agegr5_dv +
##     a_agegr10_dv + a_agegr13_dv + hh_size + n_child + hh_type
##   Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1      3565     2411.8
## 2      3565     2411.8  0        0
```

```r
# so we now belief that the following variables are predictors of non-response:
# a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size + a_sex +
#     a_gor_dv + hh_type + a_urban_dv
summary(halfbackwards)
```

```
##
## Call:
## glm(formula = NR ~ a_gor_dv + a_urban_dv + a_sex + a_dvage +
##     a_agegr5_dv + a_agegr13_dv + hh_size + n_child + hh_type,
##     family = binomial, data = society)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.75477  -0.56651  -0.40673   0.00008   2.71372
##
## Coefficients: (10 not defined because of singularities)
##                                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)                      16.76652  412.70674   0.041   0.9676
## a_gor_dvnorth west                0.37806    0.32135   1.176   0.2394
## a_gor_dvyorkshire and the humber -0.03299    0.33844  -0.097   0.9223
## a_gor_dveast midlands            -0.03274    0.35617  -0.092   0.9268
## a_gor_dvwest midlands             0.05815    0.34373   0.169   0.8657
## a_gor_dveast of england          -0.26456    0.34671  -0.763   0.4454
## a_gor_dvlondon                    0.71515    0.32162   2.224   0.0262 *
## a_gor_dvsouth east                0.47002    0.31731   1.481   0.1385
## a_gor_dvsouth west                0.53776    0.32338   1.663   0.0963 .
## a_gor_dvwales                     0.32822    0.37083   0.885   0.3761
```

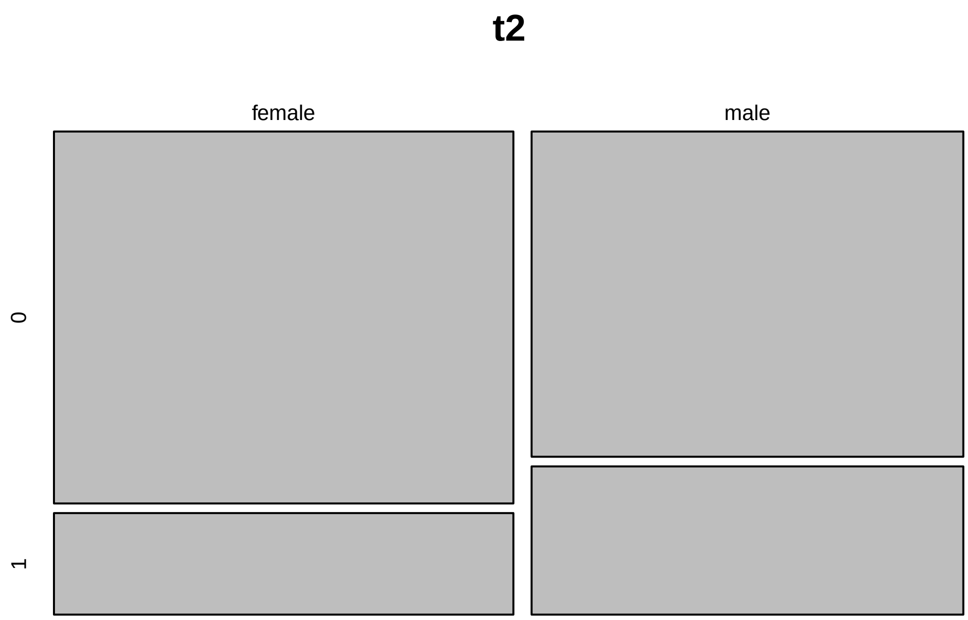
```
## a_gor_dvscotland                  0.81341    0.33349   2.439   0.0147 *
## a_urban_dvrural area              0.22087    0.13101   1.686   0.0918 .
## a_sexfemale                      -0.67411    0.10720  -6.288 3.21e-10 ***
## a_dvage                           0.05231    0.02205   2.373   0.0176 *
## a_agegr5_dv5-9 years old         -0.52228  588.26564  -0.001   0.9993
## a_agegr5_dv10-14 years old      -21.01672  412.70668  -0.051   0.9594
## a_agegr5_dv15-19 years old      -20.99819  412.70688  -0.051   0.9594
## a_agegr5_dv20-24 years old      -21.36426  412.70688  -0.052   0.9587
## a_agegr5_dv25-29 years old      -21.54627  412.70701  -0.052   0.9584
## a_agegr5_dv30-34 years old      -22.06177  412.70717  -0.053   0.9574
## a_agegr5_dv35-39 years old      -22.31341  412.70735  -0.054   0.9569
## a_agegr5_dv40-44 years old      -23.04011  412.70758  -0.056   0.9555
## a_agegr5_dv45-49 years old      -23.13002  412.70784  -0.056   0.9553
## a_agegr5_dv50-54 years old      -23.61020  412.70813  -0.057   0.9544
## a_agegr5_dv55-59 years old      -23.74167  412.70844  -0.058   0.9541
## a_agegr5_dv60-64 years old      -23.90215  412.70877  -0.058   0.9538
## a_agegr5_dv65-69 years old      -25.12335  412.70925  -0.061   0.9515
## a_agegr5_dv70 years old         -24.94935  412.71012  -0.060   0.9518
## a_agegr13_dv16-17 years old      -0.46717    0.48007  -0.973   0.3305
## a_agegr13_dv18-19 years old       0.32989    0.49018   0.673   0.5010
## a_agegr13_dv20-24 years old            NA         NA      NA       NA
## a_agegr13_dv25-29 years old            NA         NA      NA       NA
## a_agegr13_dv30-34 years old            NA         NA      NA       NA
## a_agegr13_dv35-39 years old            NA         NA      NA       NA
## a_agegr13_dv40-44 years old            NA         NA      NA       NA
## a_agegr13_dv45-49 years old            NA         NA      NA       NA
## a_agegr13_dv50-54 years old            NA         NA      NA       NA
## a_agegr13_dv55-59 years old            NA         NA      NA       NA
## a_agegr13_dv60-64 years old            NA         NA      NA       NA
## a_agegr13_dv65 years or older          NA         NA      NA       NA
## hh_size                           0.54251    0.06316   8.589  < 2e-16 ***
## n_child                          -0.19292    0.09192  -2.099   0.0358 *
## hh_typeCouple without children    0.77833    0.19700   3.951 7.78e-05 ***
## hh_typeSingle with children       0.10036    0.22853   0.439   0.6606
## hh_typeSingle without children    0.58360    0.25499   2.289   0.0221 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4142.7  on 3599  degrees of freedom
## Residual deviance: 2411.8  on 3565  degrees of freedom
## AIC: 2481.8
##
## Number of Fisher Scoring iterations: 17
```

```
# significant variables are a_dvage, hh_size, hh_type, a_sex, a_urban_dv and a_gor_dv, n_child.
# significant with p < .001 B's come from variables a_sex, hh_size and hh_type (couple without children
```

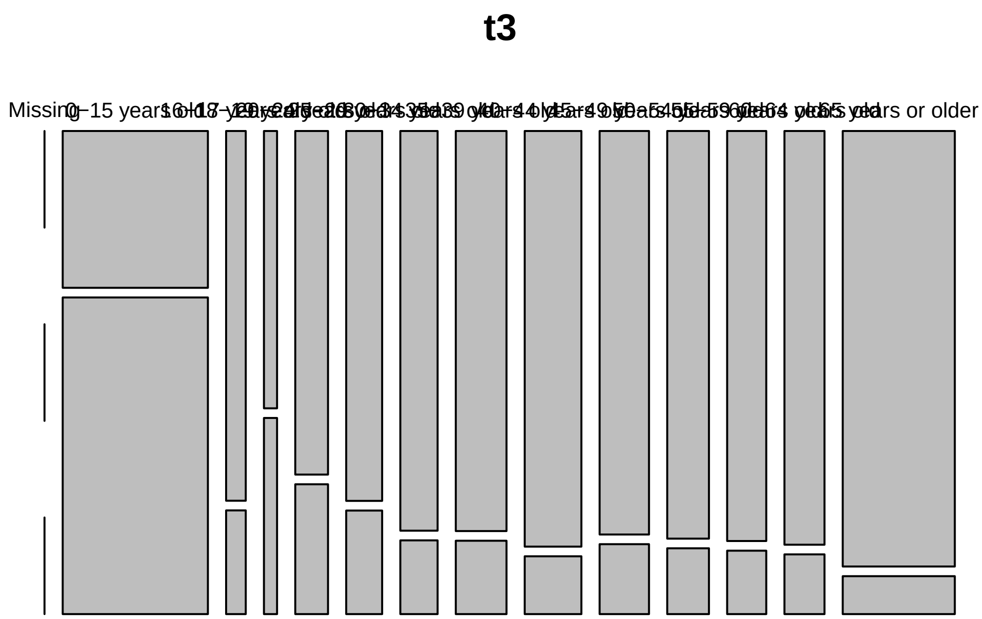
a_sex, hh_size and hh_type

hh_size - for every unit increase in household size, the odds of nonresponse increase with exp(0.32727) = 1.39. So perosns in larer households have more have a larger probability for nonresponse. a_sex - for females, the odds of nonresponse are exp(-0.67411) = compared to men. So women are … less likely to nonrespond than men. The model has very high (and unlikely) coefficients for a_agegr5_dv, this is something we unfortunately do not have the time for to further investigate although we notice that this is important. hh_size - for every unit increase in household size, the odds of nonresponse increase with exp(0.54251). hh_type - the odds for nonresponse for couples without children decrease with exp(0.77833). Compared to the other householdtypes, odds of couples without children have the lowest chance at nonresponse.

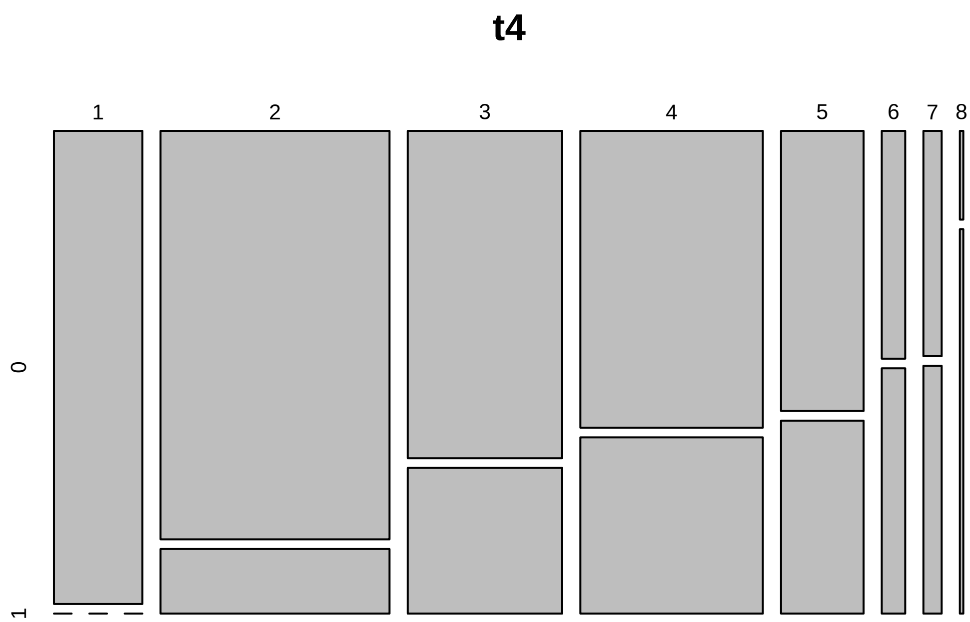
```
# plot nonresponse
tbl <- table(society$NR)
t1 <- tbl/3600*100

# plot relationship sex / nonresponse
t2 <- table(as.matrix(society$a_sex),as.matrix(society$NR))
# females respond more often then males do
plot(t2)
```




```
# plot relationship age / nonresponse
t3 <- table(society$a_agegr13_dv, society$NR)

plot(t3) # the higher the age category, the less nonresponse.
```




```
# plot relationship hh_size / non response
t4 <- table(society$hh_size, society$NR)
# the bigger the household, the more nonresponders
plot(t4)
```




```r
# plot relationship hh_type / non response
t5 <- table(society$NR, society$hh_type)
```