Appendix II: R code

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Initialization

```
# 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
```

```
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
```

```
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
```

```
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
```

```
# 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)]

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

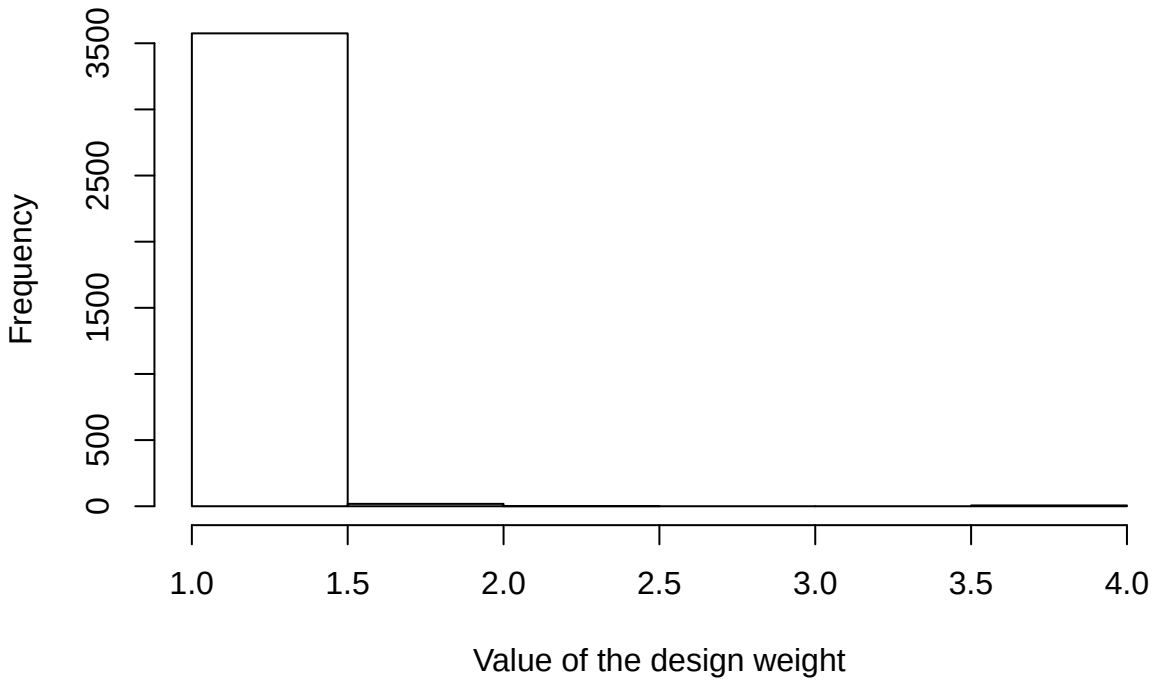
Question 2

Investigation of design weights

```
# 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
```

```
# 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

```
# 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"
```

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

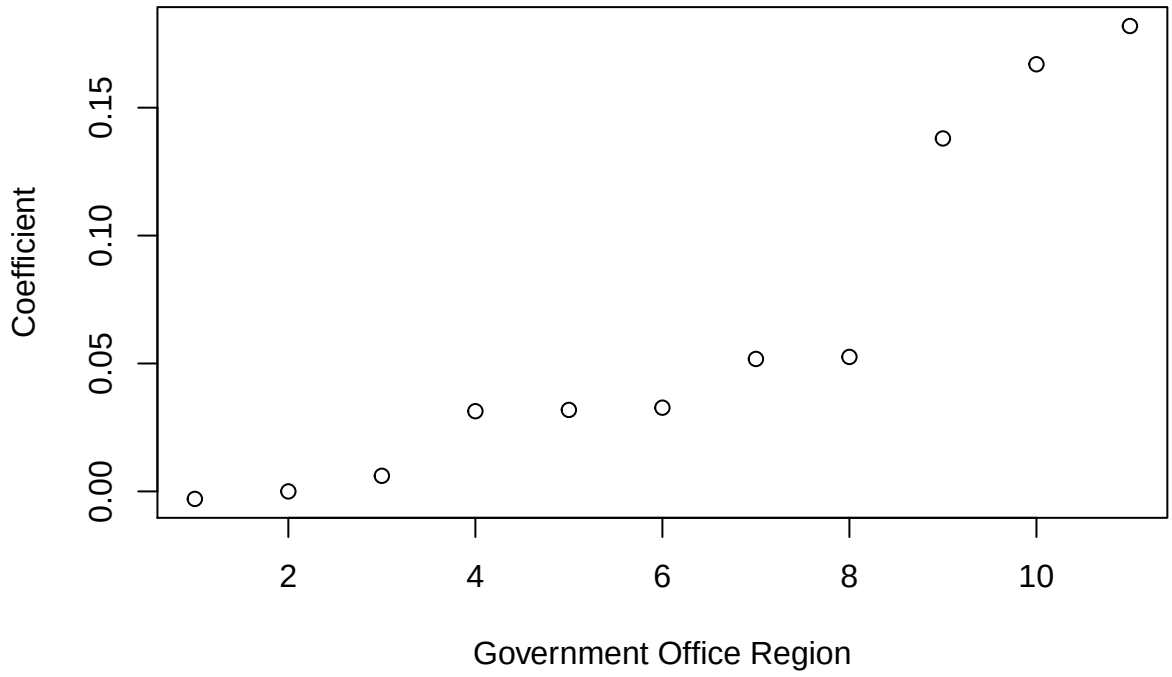
```
## [1] 0
```

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

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

```
# 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")
```

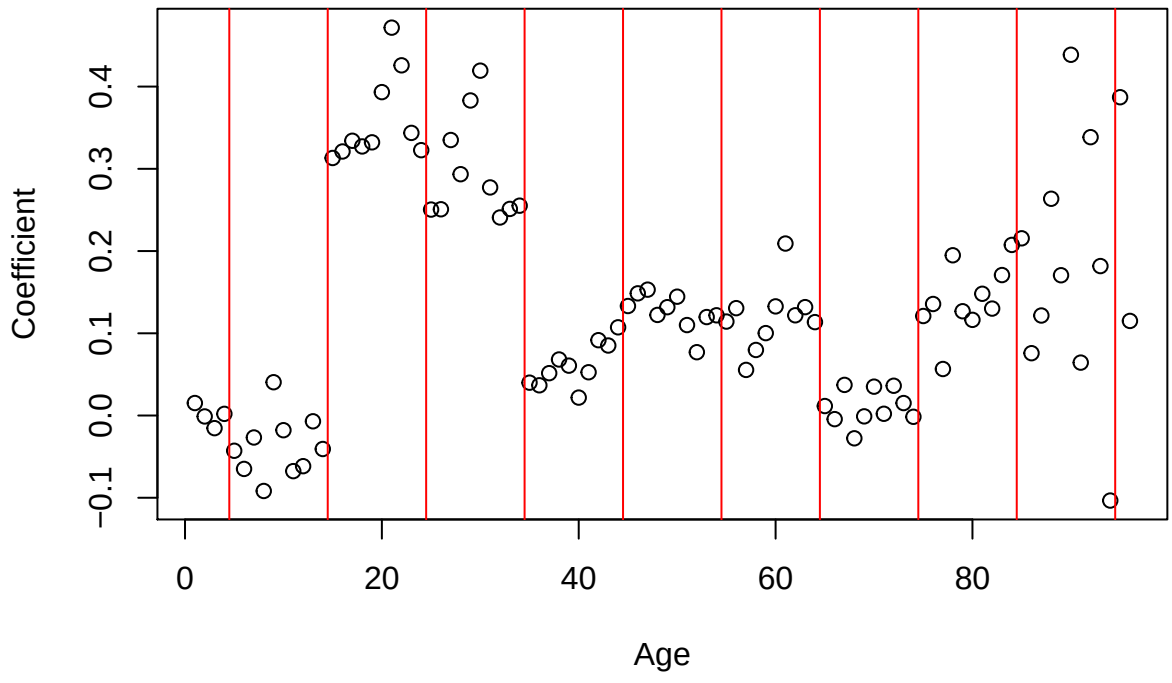



```r
# Show coefficients
coeff.gor
```

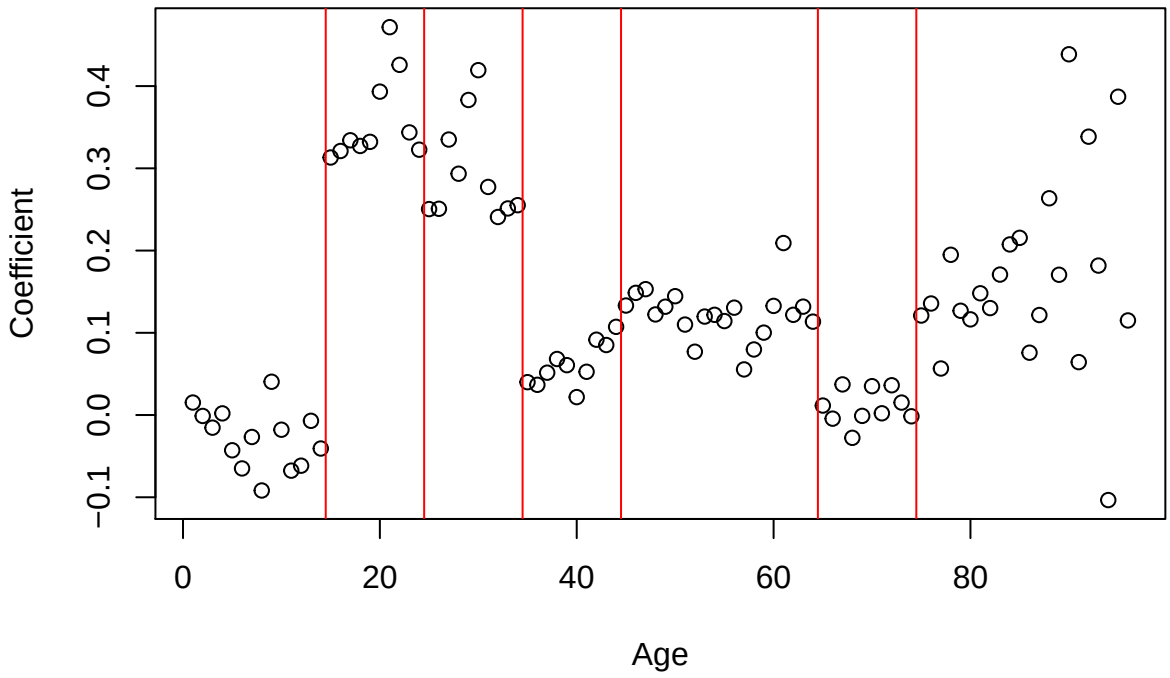
```
##              a_gor_dvnorth west a_gor_dvyorkshire and the humber
##                     0.052568228                      0.031851653
##            a_gor_dveast midlands           a_gor_dvwest midlands
##                     0.032723159                      0.137962567
##         a_gor_dveast of 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")
}
```



```
# 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.

```
# 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"
```

```
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
```

```
# 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
```

```
# 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
```

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

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

```
# 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
```

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

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

```
# 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
```

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

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

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

Question 5b

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

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

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

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

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

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

```
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"
```

```
###### 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
```

```
# 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)
```

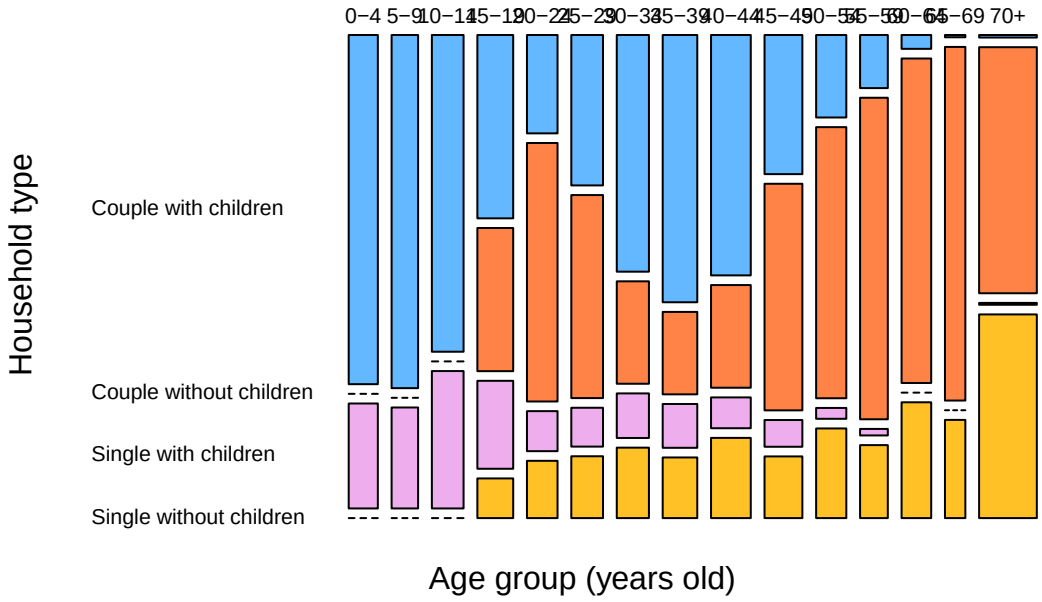
```
##
##    Couple with children Couple without children    Single with children
```

```
##                      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$a_agegr13_dv) #combine levels so no NAs exist in the contingency
levels(society$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 cat
     col=c("steelblue1","sienna1","plum2","goldenrod1"), las = 1, mar = c(3,4,4,2))
```




```
# 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
```

```
# 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
```

```
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
```

```
# >>>>>>> this is old
#png("age_householdtype", width = 1200, height = 500, res = 72)
#plot(tab, xlab = "Age group (years old)", ylab = "Household type", main = "Household types per age cat
#     col=c("steelblue1","sienna1","plum2","goldenrod1"), las = 1, mar = c(3,4,4,2)
#     )
# BLUE = couple with children
# PINK = single parent with children
# ORANGE = couple without children
# YELLOW = single without children
dev.off() # >>>>>>> what is this??
```

```
## null device
##           1
```

```
################################################################################
```

Question 6

```
# 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 - unpr
```

```
# 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))

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

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

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

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

```
# 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
```

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

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

```
# 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
```

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

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

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

Question 8

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

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

```
# 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
```

```
# 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
```

```
# 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_racel_dv + a_employ + a_dvage +
                       a_agegr5_dv + a_agegr10_dv + a_agegr13_dv + hh_size + n_child +
                       hh_type, family = binomial, data = society)

# 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=1379.35
## 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 + hh_size +
##     n_child + hh_type
```

```
##
##
## Step:  AIC=1379.35
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_employ +
##     a_dvage + a_agegr5_dv + a_agegr13_dv + hh_size + n_child +
##     hh_type
##
##                Df Deviance    AIC
## - a_employ      3   1294.0 1376.0
## - n_child       1   1291.4 1377.4
## - hh_type       3   1295.9 1377.9
## - a_dvage       1   1291.9 1377.9
## <none>              1291.3 1379.3
## - a_urban_dv    1   1293.4 1379.4
## - a_agegr13_dv  1   1293.9 1379.9
## - a_gor_dv     10   1313.8 1381.8
## - a_sex         1   1300.2 1386.2
## - hh_size       1   1304.0 1390.0
## - a_agegr5_dv   4   1634.1 1714.1
## - a_racel_dv    6   2399.7 2475.7
##
## Step:  AIC=1376
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + n_child + hh_type
##
##                Df Deviance    AIC
## - n_child       1   1294.1 1374.1
## - a_dvage       1   1294.6 1374.6
## - hh_type       3   1299.1 1375.1
## <none>              1294.0 1376.0
## - a_urban_dv    1   1296.1 1376.1
## - a_gor_dv     10   1316.4 1378.4
## - a_sex         1   1304.2 1384.2
## - hh_size       1   1306.0 1386.0
## - a_agegr13_dv  2   1324.6 1402.6
## - a_agegr5_dv   4   1635.1 1709.1
## - a_racel_dv    6   2411.8 2481.8
##
## Step:  AIC=1374.06
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_dvage + a_agegr5_dv +
##     a_agegr13_dv + hh_size + hh_type
##
##                Df Deviance    AIC
## - a_dvage       1   1294.6 1372.6
## <none>              1294.1 1374.1
## - a_urban_dv    1   1296.2 1374.2
## - hh_type       3   1301.9 1375.9
## - a_gor_dv     10   1316.4 1376.4
## - a_sex         1   1304.4 1382.4
## - hh_size       1   1312.6 1390.6
## - a_agegr13_dv  2   1325.8 1401.8
## - a_agegr5_dv   4   1635.3 1707.3
## - a_racel_dv    6   2416.2 2484.2
##
```

```
## Step:  AIC=1372.63
## NR ~ a_gor_dv + a_urban_dv + a_sex + a_racel_dv + a_agegr5_dv +
##     a_agegr13_dv + hh_size + hh_type
##
##                Df Deviance    AIC
## <none>              1294.6 1372.6
## - a_urban_dv    1   1296.8 1372.8
## - hh_type       3   1302.2 1374.2
## - a_gor_dv     10   1317.0 1375.0
## - a_sex         1   1305.0 1381.0
## - hh_size       1   1313.2 1389.2
## - a_agegr13_dv  2   1328.7 1402.7
## - a_agegr5_dv   4   1831.2 1901.2
## - a_racel_dv    6   2421.8 2487.8
```

```
# 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_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_dvage       1   3336.2 3340.2
## + a_employ      4   3348.4 3358.4
## + 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=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_employ      4   1912.2 1934.2
## + hh_type       3   1967.0 1987.0
## + a_sex         1   2000.6 2016.6
## + hh_size       1   2003.5 2019.5
## + 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_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_sex         1   1393.0 1437.0
## + 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
##
## Step:  AIC=1406.48
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv
##
##              Df Deviance    AIC
## + hh_size     1   1336.1 1384.1
## + a_sex       1   1349.4 1397.4
## + hh_type     3   1346.7 1398.7
## + n_child     1   1354.9 1402.9
## + a_urban_dv  1   1358.4 1406.4
## <none>            1360.5 1406.5
## + a_gor_dv   10   1340.6 1406.6
## + a_dvage     1   1360.2 1408.2
## + a_employ    3   1356.9 1408.9
##
## Step:  AIC=1384.09
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size
##
##              Df Deviance    AIC
## + a_sex       1   1325.2 1375.2
## + hh_type     3   1328.8 1382.8
## + n_child     1   1333.6 1383.6
## + a_gor_dv   10   1315.7 1383.7
## <none>            1336.1 1384.1
## + a_urban_dv  1   1334.2 1384.2
## + a_employ    3   1330.6 1384.6
## + a_dvage     1   1335.7 1385.7
##
## Step:  AIC=1375.25
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size + a_sex
##
##              Df Deviance    AIC
## + a_gor_dv   10   1304.9 1374.9
## + hh_type     3   1318.9 1374.9
## + a_urban_dv  1   1323.0 1375.0
## <none>            1325.2 1375.2
## + n_child     1   1323.4 1375.4
## + a_dvage     1   1324.8 1376.8
## + a_employ    3   1321.5 1377.5
##
## Step:  AIC=1374.86
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size + a_sex +
##     a_gor_dv
##
```

```
##              Df Deviance    AIC
## + hh_type     3   1296.8 1372.8
## + n_child     1   1301.7 1373.7
## + a_urban_dv  1   1302.2 1374.2
## <none>            1304.9 1374.9
## + a_dvage     1   1304.5 1376.5
## + a_employ    3   1301.1 1377.1
##
## Step:  AIC=1372.79
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size + a_sex +
##     a_gor_dv + hh_type
##
##              Df Deviance    AIC
## + a_urban_dv  1   1294.6 1372.6
## <none>            1296.8 1372.8
## + a_dvage     1   1296.2 1374.2
## + n_child     1   1296.7 1374.7
## + a_employ    3   1294.1 1376.1
##
## Step:  AIC=1372.63
## NR ~ a_racel_dv + a_agegr5_dv + a_agegr13_dv + hh_size + a_sex +
##     a_gor_dv + hh_type + a_urban_dv
##
##            Df Deviance    AIC
## <none>          1294.6 1372.6
## + a_dvage   1   1294.1 1374.1
## + n_child   1   1294.6 1374.6
## + a_employ  3   1292.0 1376.0
```

```
# 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
```

```
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
```

```
formula(forwards)
```

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

```
formula(halfforwards)
```

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

```
formula(halffullmodel)
```

```
## 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 + hh_size +
##     n_child + hh_type
```

```r
formula(halfbackwards)
```

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

```r
# 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_racel_dv +
##     a_agegr5_dv + a_agegr13_dv + hh_size + hh_type, family = binomial,
##     data = society)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.4932  -0.3487  -0.2330   0.0001   3.9325
##
## Coefficients: (10 not defined because of singularities)
##                                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)                        18.15987  689.32392   0.026  0.97898
## a_gor_dvnorth west                  0.54928    0.50490   1.088  0.27665
## a_gor_dvyorkshire and the humber    0.23904    0.52235   0.458  0.64722
## a_gor_dveast midlands              -0.14401    0.57453  -0.251  0.80207
## a_gor_dvwest midlands               0.47888    0.52777   0.907  0.36421
## a_gor_dveast of england            -0.14253    0.54241  -0.263  0.79273
## a_gor_dvlondon                      0.58688    0.51243   1.145  0.25209
## a_gor_dvsouth east                  0.84116    0.49214   1.709  0.08742
## a_gor_dvsouth west                  0.49277    0.51426   0.958  0.33796
## a_gor_dvwales                       0.18818    0.60303   0.312  0.75499
## a_gor_dvscotland                    1.16013    0.51151   2.268  0.02333
## a_urban_dvrural area                0.28284    0.19050   1.485  0.13761
## a_sexfemale                        -0.49673    0.15540  -3.196  0.00139
## a_racel_dvUK Native                -6.40958    0.36410 -17.604  < 2e-16
## a_racel_dvWhite - Nonnative        -6.02550    0.63409  -9.503  < 2e-16
## a_racel_dvMixed                    -5.83151    0.84204  -6.925 4.35e-12
## a_racel_dvAsian or Asian British   -5.45720    0.46950 -11.623  < 2e-16
## a_racel_dvBlack/African/Carribean  -6.47857    0.82457  -7.857 3.94e-15
## a_racel_dvOther                    -6.46329    0.72446  -8.922  < 2e-16
## a_agegr5_dv5-9 years old           -0.23333  981.11604   0.000  0.99981
## a_agegr5_dv10-14 years old        -21.12668  689.32372  -0.031  0.97555
## a_agegr5_dv15-19 years old        -19.44553  689.32392  -0.028  0.97750
## a_agegr5_dv20-24 years old        -15.91029  689.32388  -0.023  0.98159
## a_agegr5_dv25-29 years old        -15.86298  689.32386  -0.023  0.98164
## a_agegr5_dv30-34 years old        -16.16052  689.32386  -0.023  0.98130
## a_agegr5_dv35-39 years old        -16.35101  689.32384  -0.024  0.98108
## a_agegr5_dv40-44 years old        -16.68888  689.32385  -0.024  0.98068
## a_agegr5_dv45-49 years old        -16.13855  689.32385  -0.023  0.98132
## a_agegr5_dv50-54 years old        -16.26146  689.32388  -0.024  0.98118
## a_agegr5_dv55-59 years old        -16.13181  689.32388  -0.023  0.98133
## a_agegr5_dv60-64 years old        -16.21021  689.32389  -0.024  0.98124
## a_agegr5_dv65-69 years old        -17.43135  689.32404  -0.025  0.97983
## a_agegr5_dv70 years old           -16.75895  689.32387  -0.024  0.98060
## a_agegr13_dv16-17 years old         3.46894    0.75324   4.605 4.12e-06
## a_agegr13_dv18-19 years old         4.48115    0.75431   5.941 2.84e-09
```

```
## 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                            0.32727    0.07485   4.372 1.23e-05
## hh_typeCouple without children     0.53579    0.24882   2.153  0.03129
## hh_typeSingle with children       -0.18336    0.29446  -0.623  0.53348
## hh_typeSingle without children     0.08884    0.39247   0.226  0.82093
##
## (Intercept)
## a_gor_dvnorth west
## a_gor_dvyorkshire and the humber
## a_gor_dveast midlands
## a_gor_dvwest midlands
## a_gor_dveast of england
## a_gor_dvlondon
## a_gor_dvsouth east                .
## a_gor_dvsouth west
## a_gor_dvwales
## a_gor_dvscotland                  *
## a_urban_dvrural area
## a_sexfemale                       **
## a_racel_dvUK Native               ***
## a_racel_dvWhite - Nonnative       ***
## a_racel_dvMixed                   ***
## a_racel_dvAsian or Asian British  ***
## a_racel_dvBlack/African/Carribean ***
## a_racel_dvOther                   ***
## a_agegr5_dv5-9 years old
## a_agegr5_dv10-14 years old
## a_agegr5_dv15-19 years old
## a_agegr5_dv20-24 years old
## a_agegr5_dv25-29 years old
## a_agegr5_dv30-34 years old
## a_agegr5_dv35-39 years old
## a_agegr5_dv40-44 years old
## a_agegr5_dv45-49 years old
## a_agegr5_dv50-54 years old
## a_agegr5_dv55-59 years old
## a_agegr5_dv60-64 years old
## a_agegr5_dv65-69 years old
## a_agegr5_dv70 years old
## a_agegr13_dv16-17 years old       ***
## a_agegr13_dv18-19 years old       ***
## a_agegr13_dv20-24 years old
## a_agegr13_dv25-29 years old
## a_agegr13_dv30-34 years old
## a_agegr13_dv35-39 years old
```

```
## a_agegr13_dv40-44 years old
## a_agegr13_dv45-49 years old
## a_agegr13_dv50-54 years old
## a_agegr13_dv55-59 years old
## a_agegr13_dv60-64 years old
## a_agegr13_dv65 years or older
## hh_size                          ***
## hh_typeCouple without children    *
## hh_typeSingle with children
## hh_typeSingle without children
## ---
## 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: 1294.6  on 3561  degrees of freedom
## AIC: 1372.6
##
## Number of Fisher Scoring iterations: 18
```

```
# significant variables are a_agegr13, hh_size, hh_type, sex, urban and a_gor
# significant with p < .001 are sex, a_agegr13_dv and hh_size. plot those (see below)

# evaluate fit
fit <- anova(halfbackwards, halffullmodel)
library(lmtest)
```

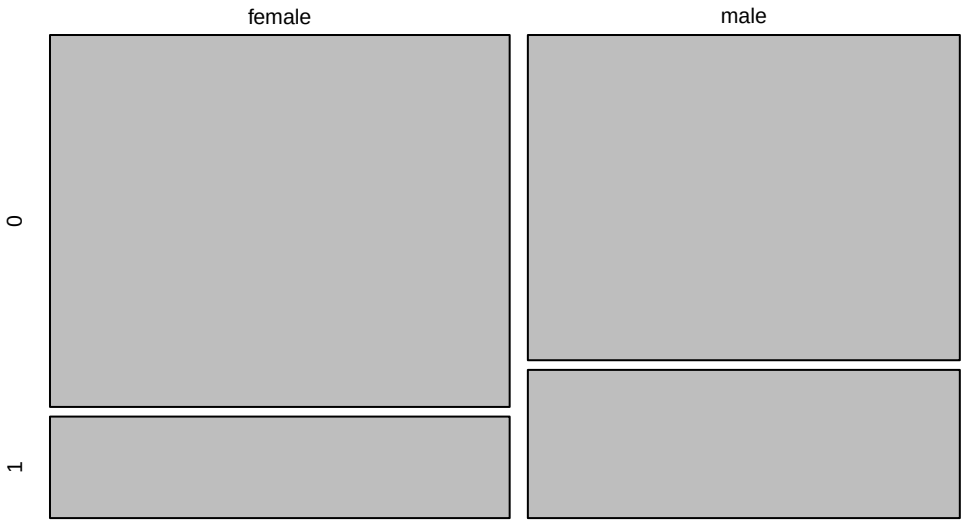
```
## Warning: package 'lmtest' was built under R version 3.4.4
```

```
## Loading required package: zoo
```

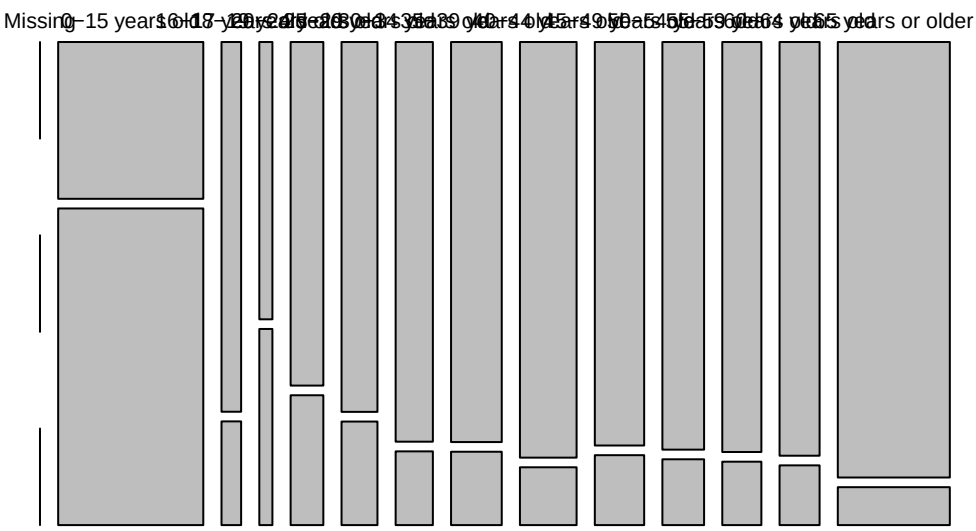
```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

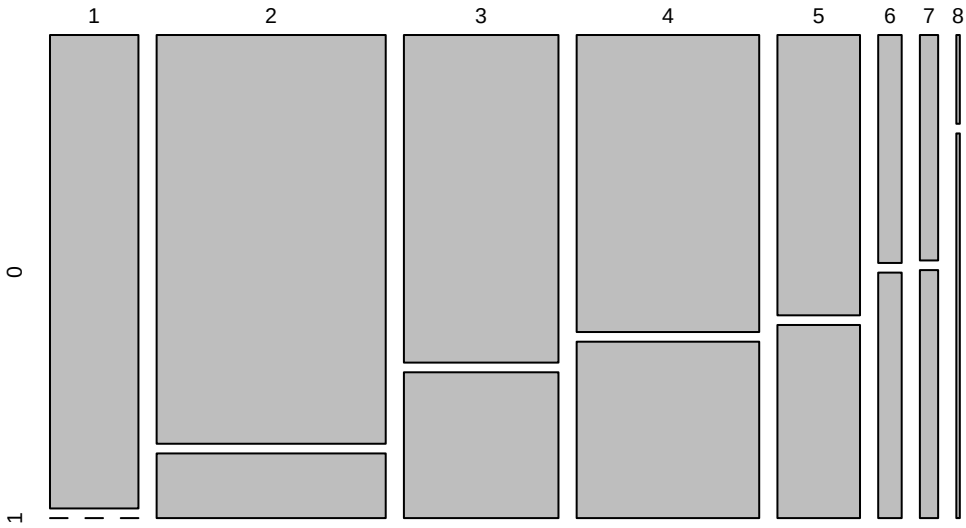
```
test <- lrtest(halfbackwards,halffullmodel)

# interesting: a_agegr13_dv produces NA's for every category except 16-17 and 18-19 years old..?
# i tried to load all kinds of packages to compute a pseudo r squared but they didn't work..

# 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)
```


t4
1
2
3
4
5
6
7
8
0
1