Q1) satisfaction was high in tower blocks with high contact. Satisfaction was lower in apartments or houses than in tower blocks. Contact was lower in tower blocks.

satisfaction vs housing type and contact

Row Labels	high	low	medium	Grand Total
apartment	**302**	**271**	**192**	**765**
high	191	141	116	448
low	111	130	76	317
house	**166**	**197**	**153**	**516**
high	104	130	105	339
low	62	67	48	177
tower block	**200**	**99**	**101**	**400**
high	100	34	47	181
low	100	65	54	219
Grand Total	**668**	**567**	**446**	**1681**

satisfaction vs housing type

Row Labels	high	low	medium	Grand Total
apartment	302	271	192	765
house	166	197	153	516
tower block	200	99	101	400
Grand Total	**668**	**567**	**446**	**1681**

satisfaction vs contact

Row Labels	high	low	medium	Grand Total
high	395	305	268	968
low	273	262	178	713
Grand Total	**668**	**567**	**446**	**1681**

b) nominal logistic regression model, with main effects (house type and contact), fits the data fairly well. Most of the parameter estimates are significantly different from zero. Adding interactions doesn't improve the model significantly. (deviance = 6.893, d.f. = 4, p-value = 0.142).

multinom(formula = satisfaction ~ type + contact, data = housing, weights = frequency)

```
Coefficients:
       (Intercept) typehouse typetower block contactlow
low     -0.2474055 0.3040225      -0.6415725  0.3282260
medium  -0.4654412 0.3736997      -0.2348298  0.0322483

Residual Deviance: 3605.48
AIC: 3621.48
```

*multinom(formula = satisfaction ~ type * contact, data = housing, weights = frequency)*

```
Coefficients:
       (Intercept) typehouse typetower block contactlow typehouse:contactlow
low     -0.3035132 0.5266530      -0.7752954  0.4615143           -0.6070980
medium  -0.4986823 0.5082498      -0.2563440  0.1198824           -0.3853824
       typetower block:contactlow
low                    0.18651002
medium                 0.01895961

Residual Deviance: 3598.587
AIC: 3622.587
```

c) we can fit ordinal logistic regression as satisfaction is an ordinal variable. Adding interactions to main effect model doesn't make much improvement according to Deviance test (deviance = 3.54, d.f. = 2, p-value = 0.17)

polr(formula = factor(satisfaction) ~ type + contact, data = housing, weights = frequency)

```
Coefficients:
      typehouse typetower block      contactlow
     0.27590184     -0.29240512      0.07453312

Intercepts:
  high|low low|medium
-0.3671175  1.0816822

Residual Deviance: 3628.55
AIC: 3638.55
```

*polr(formula = factor(satisfaction) ~ type * contact, data = housing, weights = frequency)*

```
Coefficients:
                 typehouse            typetower block          contactlow
                 0.3967830                 -0.3653536          0.1502266
                 typehouse:contactlow typetower block:contactlow
                -0.3326654                  0.1090346

Intercepts:
  high|low low|medium
-0.3353559  1.1158384

Residual Deviance: 3625.007
AIC: 3639.007
```

d) we can get probabilities by fitted(glm) in R and multiply by number of type,contact to get estimate d freq. Nominal and ordinal logistic regression models produce similar parameter estimates and simi lar fitted values in this case. On the grounds of parsimony we choose the ordinal model. The fit of the nominal logistic regression model is shown in the table below. The biggest residual is highlighted in r ed color.

type	satisfaction	contact	frequency	estimated freq	std residuals
tower block	low	low	65	60.00	0.08
tower block	low	high	34	39.01	-0.13
tower block	medium	low	54	53.89	0.00
tower block	medium	high	47	47.11	0.00
tower block	high	low	100	105.11	-0.05
tower block	high	high	100	94.89	0.05
apartment	low	low	130	125.77	0.03
apartment	low	high	141	145.23	-0.03
apartment	medium	low	76	75.22	0.01
apartment	medium	high	116	116.78	-0.01
apartment	high	low	111	116.01	-0.04
apartment	high	high	191	185.99	0.03
house	low	low	67	76.23	-0.12
house	low	high	130	120.77	0.08
house	medium	low	48	48.89	-0.02
house	medium	high	105	104.12	0.01
house	high	low	62	51.88	0.20
house	high	high	104	114.12	-0.09

Appendix: R code

```
require(dobson)
require(ggplot2)
library(nnet)
library(MASS)

#preparation of data
housing <- dobson::housing
housing$type <- as.factor(housing$type)
housing$contact <- as.factor(housing$contact)

#model of interest
res.housing=multinom(satisfaction ~ type + contact,
                  weights=frequency, data=housing)
summary(res.housing)

# full model
res.housing.full =multinom(satisfaction ~  type * contact,
                       weights=frequency, data=housing)
summary(res.housing.full)


# deviance test
delta_deviance = deviance(res.housing) - deviance(res.housing.full)
# delta_df = 4 because df.residual(res.housing.full)=12 , df.residual(res.hou
sing) = 8
# p_value > 0.05 so dont reject H0
p_value = 1-pchisq(delta_deviance, df= 4)

res.housing.polr = polr(factor(satisfaction) ~ type + contact,
                        weights=frequency, data=housing)

res.housing.polr.full = polr(factor(satisfaction) ~ type * contact,
                        weights=frequency, data=housing)

# deviance test
delta_deviance = deviance(res.housing.polr) - deviance(res.housing.polr.full)
# p_value > 0.05 so dont reject H0
p_value = 1-pchisq(delta_deviance, df= 4)

#fitted value and residual
fitted(res.housing)
fitted(res.housing.polr)
res.housing$residuals
```