R Notebook

Data

Assessment Data

```
str(data.ecpe$data)
```

```
## 'data.frame':    2922 obs. of  29 variables:
##  $ id : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ E1 : int  1 1 1 1 1 1 1 0 1 1 ...
##  $ E2 : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E3 : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E4 : int  0 1 1 1 1 1 1 1 1 1 ...
##  $ E5 : int  1 1 1 1 1 1 1 1 1 0 ...
##  $ E6 : int  1 1 1 1 1 1 1 1 1 0 ...
##  $ E7 : int  1 1 0 1 1 1 1 0 1 1 ...
##  $ E8 : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E9 : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E10: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E11: int  1 1 1 1 1 1 1 1 0 1 1 ...
##  $ E12: int  1 1 1 1 0 1 1 1 0 0 ...
##  $ E13: int  1 1 1 1 1 1 1 1 0 1 1 ...
##  $ E14: int  1 1 1 1 1 1 1 1 0 1 1 ...
##  $ E15: int  1 1 1 1 1 1 1 1 1 1 1 ...
##  $ E16: int  1 1 1 1 1 1 1 1 1 1 1 ...
##  $ E17: int  1 0 1 1 1 1 1 1 1 1 ...
##  $ E18: int  1 1 1 1 0 1 1 0 1 1 ...
##  $ E19: int  1 1 1 1 0 1 1 1 1 1 ...
##  $ E20: int  1 1 1 1 1 1 1 1 0 0 0 ...
##  $ E21: int  1 1 1 1 1 1 0 0 1 1 0 ...
##  $ E22: int  1 1 1 1 1 0 1 1 1 1 0 ...
##  $ E23: int  1 1 1 1 1 1 1 1 1 1 0 ...
##  $ E24: int  0 0 1 1 1 1 1 1 0 1 0 ...
##  $ E25: int  1 1 1 1 1 1 1 1 1 1 1 ...
##  $ E26: int  1 1 1 1 1 1 1 1 1 1 1 ...
##  $ E27: int  1 1 1 1 1 1 1 1 0 1 1 ...
##  $ E28: int  1 1 1 1 1 1 1 1 1 1 1 ...
```

Q Matrix:

```
str(data.ecpe$q.matrix)
```

```
## 'data.frame':    28 obs. of  3 variables:
##  $ skill1: int  1 0 1 0 0 0 1 0 0 1 ...
##  $ skill2: int  1 1 0 0 0 0 0 1 0 0 ...
##  $ skill3: int  0 0 1 1 1 1 1 0 1 0 ...
```

Model

DINA

```
ecpe.dina <- din(data.ecpe$data[,-1], data.ecpe$q.matrix,progress = FALSE)
ecpe.dina
```

```
## Estimation of Mixed DINA/DINO Model
##
## CDM 7.2-30 (2019-02-08 11:13:48)
##
## Call:
## din(data = data.ecpe$data[, -1], q.matrix = data.ecpe$q.matrix,
##     progress = FALSE)
##
## Number of cases=2922
## Number of items=28
## Number of skill dimensions=3
## Number of skill classes=8
## Number of parameters=63
##   # item parameters=56
##   # skill distribution parameters=7
##
## Log-Likelihood=-42843.46
## AIC=85813
## BIC=86190
```

Guess parameters

```
str(ecpe.dina$guess)
```

```
## 'data.frame':    28 obs. of  2 variables:
##  $ est: num  0.705 0.724 0.438 0.48 0.764 ...
##  $ se : num  0.0121 0.0163 0.0135 0.0156 0.0132 ...
```

Slip parameters

```
str(ecpe.dina$slip)
```

```
## 'data.frame':    28 obs. of  2 variables:
##  $ est: num  0.085 0.1009 0.2657 0.162 0.0405 ...
##  $ se : num  0.00902 0.00739 0.01297 0.00998 0.0053 ...
```

Coefficients, Standard errors and Confidence intervals for all parameters

```
param <- IRT.se(ecpe.dina, extended=TRUE)
head(param)
```

```
##   partype parindex parameter        est          se      2.5 %    97.5 %
## 1   guess        1  E1_guess 0.70533412 0.012560214 0.68071655 0.7299517
```

```
## 2    slip        2   E1_slip 0.08503517 0.009349528 0.06671043 0.1033599
## 3   guess        3  E2_guess 0.72380564 0.015572108 0.69328487 0.7543264
## 4    slip        4   E2_slip 0.10092311 0.008886350 0.08350618 0.1183400
## 5   guess        5  E3_guess 0.43810306 0.013806867 0.41104210 0.4651640
## 6    slip        6   E3_slip 0.26573233 0.013341317 0.23958383 0.2918808
##   item item.name skillclass fixed free rule totindex
## 1    1        E1          0 FALSE TRUE DINA        1
## 2    1        E1          0 FALSE TRUE DINA        2
## 3    2        E2          0 FALSE TRUE DINA        3
## 4    2        E2          0 FALSE TRUE DINA        4
## 5    3        E3          0 FALSE TRUE DINA        5
## 6    3        E3          0 FALSE TRUE DINA        6
```

```
tail(param, 15)
```

```
##      partype parindex   parameter         est          se        2.5 %
## 53     guess       53   E27_guess 0.265058323 0.013032363  0.239515360
## 54      slip       54    E27_slip 0.368672363 0.014472118  0.340307533
## 55     guess       55   E28_guess 0.659114938 0.016216248  0.627331676
## 56      slip       56    E28_slip 0.086070455 0.007426670  0.071514450
## 57     probs       57 prob_class1 0.311074178 0.016615891  0.278507630
## 58     probs       58 prob_class2 0.006133434 0.008651352 -0.010822903
## 59     probs       59 prob_class3 0.040339807 0.012668820  0.015509376
## 60     probs       60 prob_class4 0.049576658 0.010517344  0.028963042
## 61     probs       61 prob_class5 0.012468516 0.007852105 -0.002921327
## 62     probs       62 prob_class6 0.025885034 0.007090650  0.011987615
## 63     probs       63 prob_class7 0.103326045 0.011238043  0.081299885
## 64     probs        0 prob_class8 0.451196328 0.015248987  0.421308863
## 65 margprobs        0 prob_skill1 0.495683312 0.015579641  0.465147776
## 66 margprobs        0 prob_skill2 0.607330696 0.016681737  0.574635092
## 67 margprobs        0 prob_skill3 0.629984064 0.012975243  0.604553056
##        97.5 % item item.name skillclass fixed  free rule totindex
## 53 0.29060129   27       E27          0 FALSE  TRUE DINA       53
## 54 0.39703719   27       E27          0 FALSE  TRUE DINA       54
## 55 0.69089820   28       E28          0 FALSE  TRUE DINA       55
## 56 0.10062646   28       E28          0 FALSE  TRUE DINA       56
## 57 0.34364073    0                    1 FALSE  TRUE            57
## 58 0.02308977    0                    2 FALSE  TRUE            58
## 59 0.06517024    0                    3 FALSE  TRUE            59
## 60 0.07019027    0                    4 FALSE  TRUE            60
## 61 0.02785836    0                    5 FALSE  TRUE            61
## 62 0.03978245    0                    6 FALSE  TRUE            62
## 63 0.12535221    0                    7 FALSE  TRUE            63
## 64 0.48108379    0                    8 FALSE FALSE            64
## 65 0.52621885    0                    0 FALSE FALSE            65
## 66 0.64002630    0                    0 FALSE FALSE            66
## 67 0.65541507    0                    0 FALSE FALSE            67
```

Let's separate each type of parameter

```
p <- split(param, param$partype)
```

Item characteristics

Item p-values

```r
pvalues <- colMeans(data.ecpe$data[,-1], na.rm=TRUE)
pvalues
```

```
##        E1        E2        E3        E4        E5        E6        E7
## 0.8025325 0.8302533 0.5793977 0.7056810 0.8870637 0.8535250 0.7210815
##        E8        E9       E10       E11       E12       E13       E14
## 0.8980151 0.7022587 0.6584531 0.7207392 0.4332649 0.7546201 0.6512663
##       E15       E16       E17       E18       E19       E20       E21
## 0.8819302 0.7043121 0.8856947 0.8456537 0.7104723 0.4609856 0.7559890
##       E22       E23       E24       E25       E26       E27       E28
## 0.6307324 0.8117728 0.5349076 0.6190965 0.7026010 0.4466119 0.8196441
```

Guessing parameter

```r
head(p$guess)
```

```
##    partype parindex parameter       est         se     2.5 %    97.5 %
## 1    guess        1  E1_guess 0.7053341 0.01256021 0.6807166 0.7299517
## 3    guess        3  E2_guess 0.7238056 0.01557211 0.6932849 0.7543264
## 5    guess        5  E3_guess 0.4381031 0.01380687 0.4110421 0.4651640
## 7    guess        7  E4_guess 0.4804197 0.01738231 0.4463510 0.5144884
## 9    guess        9  E5_guess 0.7636764 0.01391434 0.7364048 0.7909480
## 11   guess       11  E6_guess 0.7173405 0.01507642 0.6877912 0.7468897
##    item item.name skillclass fixed free rule totindex
## 1     1        E1          0 FALSE TRUE DINA        1
## 3     2        E2          0 FALSE TRUE DINA        3
## 5     3        E3          0 FALSE TRUE DINA        5
## 7     4        E4          0 FALSE TRUE DINA        7
## 9     5        E5          0 FALSE TRUE DINA        9
## 11    6        E6          0 FALSE TRUE DINA       11
```

Slipping parameter

```r
head(p$slip)
```

```
##    partype parindex parameter        est          se      2.5 %     97.5 %
## 2     slip        2   E1_slip 0.08503517 0.009349528 0.06671043 0.10335990
## 4     slip        4   E2_slip 0.10092311 0.008886350 0.08350618 0.11834004
## 6     slip        6   E3_slip 0.26573233 0.013341317 0.23958383 0.29188084
## 8     slip        8   E4_slip 0.16201356 0.009833474 0.14274030 0.18128681
## 10    slip       10   E5_slip 0.04046587 0.005295011 0.03008784 0.05084390
## 12    slip       12   E6_slip 0.06648817 0.006745318 0.05326759 0.07970875
##    item item.name skillclass fixed free rule totindex
## 2     1        E1          0 FALSE TRUE DINA        2
## 4     2        E2          0 FALSE TRUE DINA        4
## 6     3        E3          0 FALSE TRUE DINA        6
## 8     4        E4          0 FALSE TRUE DINA        8
## 10    5        E5          0 FALSE TRUE DINA       10
## 12    6        E6          0 FALSE TRUE DINA       12
```

Item Discrimination parameter

```
omega1 <- 1 - p$guess$est - p$slip$est

omega1
```

```
##  [1] 0.2096307 0.1752712 0.2961646 0.3575668 0.1958577 0.2161714 0.3715582
##  [8] 0.1584298 0.2665006 0.3545077 0.3448425 0.5002311 0.2452491 0.2714919
## [15] 0.2111494 0.3250726 0.1264873 0.1846670 0.3766195 0.4657007 0.2819769
## [22] 0.4904499 0.2876592 0.3645829 0.2166230 0.2343462 0.3662693 0.2548146
```

Item Easiness parameter

```
omega2 <- (p$guess$est + (1 - p$slip$est))/2

omega2
```

```
##  [1] 0.8101495 0.8114413 0.5861854 0.6592031 0.8616053 0.8254261 0.7295971
##  [8] 0.8810107 0.6676179 0.6599834 0.7286425 0.4447295 0.7556788 0.6524382
## [15] 0.8544841 0.7117623 0.8787983 0.8216499 0.6615177 0.4716589 0.7624516
## [22] 0.5669817 0.7808981 0.4957767 0.6200316 0.6721397 0.4481930 0.7865222
```

Skills Characteristics

Skills Distribution

```
p$margprobs
```

```
##      partype parindex   parameter       est         se     2.5 %    97.5 %
## 65 margprobs        0 prob_skill1 0.4956833 0.01557964 0.4651478 0.5262188
## 66 margprobs        0 prob_skill2 0.6073307 0.01668174 0.5746351 0.6400263
## 67 margprobs        0 prob_skill3 0.6299841 0.01297524 0.6045531 0.6554151
##    item item.name skillclass fixed  free rule totindex
## 65    0                   0 FALSE FALSE            65
## 66    0                   0 FALSE FALSE            66
## 67    0                   0 FALSE FALSE            67
```

Skills Class Distribution

```
p$probs
```

```
##    partype parindex   parameter         est          se        2.5 %
## 57   probs       57 prob_class1 0.311074178 0.016615891  0.278507630
## 58   probs       58 prob_class2 0.006133434 0.008651352 -0.010822903
## 59   probs       59 prob_class3 0.040339807 0.012668820  0.015509376
## 60   probs       60 prob_class4 0.049576658 0.010517344  0.028963042
## 61   probs       61 prob_class5 0.012468516 0.007852105 -0.002921327
## 62   probs       62 prob_class6 0.025885034 0.007090650  0.011987615
## 63   probs       63 prob_class7 0.103326045 0.011238043  0.081299885
## 64   probs        0 prob_class8 0.451196328 0.015248987  0.421308863
##        97.5 % item item.name skillclass fixed  free rule totindex
## 57 0.34364073    0                   1 FALSE  TRUE            57
## 58 0.02308977    0                   2 FALSE  TRUE            58
## 59 0.06517024    0                   3 FALSE  TRUE            59
## 60 0.07019027    0                   4 FALSE  TRUE            60
## 61 0.02785836    0                   5 FALSE  TRUE            61
```

```
## 62 0.03978245    0                   6 FALSE  TRUE           62
## 63 0.12535221    0                   7 FALSE  TRUE           63
## 64 0.48108379    0                   8 FALSE FALSE           64
```

Individual Skills profile

```
skill.p <- IRT.factor.scores(ecpe.dina, type="MLE")
head(skill.p)
```

```
##      MLE.skill1 MLE.skill2 MLE.skill3
## [1,]          1          1          1
## [2,]          1          0          1
## [3,]          1          1          1
## [4,]          1          1          1
## [5,]          1          1          1
## [6,]          1          1          1
```

```
summary(ecpe.dina)
```

```
## CDM 7.2-30 (Built 2019-02-08 11:13:48)
```

```
## Call:
##  din(data = data.ecpe$data[, -1], q.matrix = data.ecpe$q.matrix,      progress = FALSE)
##
## Date of Analysis: 2019-03-19 21:36:07
## Time difference of 0.4336622 secs
## Computation Time: 0.4336622
##
##
## Deviance = 85686.92  |   Log-Likelihood= -42843.46
##
## Number of iterations: 40
##
## Number of item parameters: 56
## Number of skill class parameters: 7
##
## Information criteria:
##   AIC = 85812.92
##   BIC = 86189.66
##
## Mean of RMSEA item fit: 0.02
##
## Item parameters
##    item guess  slip   IDI rmsea
## 1    E1 0.705 0.085 0.210 0.016
## 2    E2 0.724 0.101 0.175 0.010
## 3    E3 0.438 0.266 0.296 0.021
## 4    E4 0.480 0.162 0.358 0.021
## 5    E5 0.764 0.040 0.196 0.011
## 6    E6 0.717 0.066 0.216 0.011
## 7    E7 0.544 0.085 0.372 0.029
## 8    E8 0.802 0.040 0.158 0.010
## 9    E9 0.534 0.199 0.266 0.037
## 10  E10 0.483 0.163 0.354 0.011
## 11  E11 0.556 0.099 0.345 0.034
```

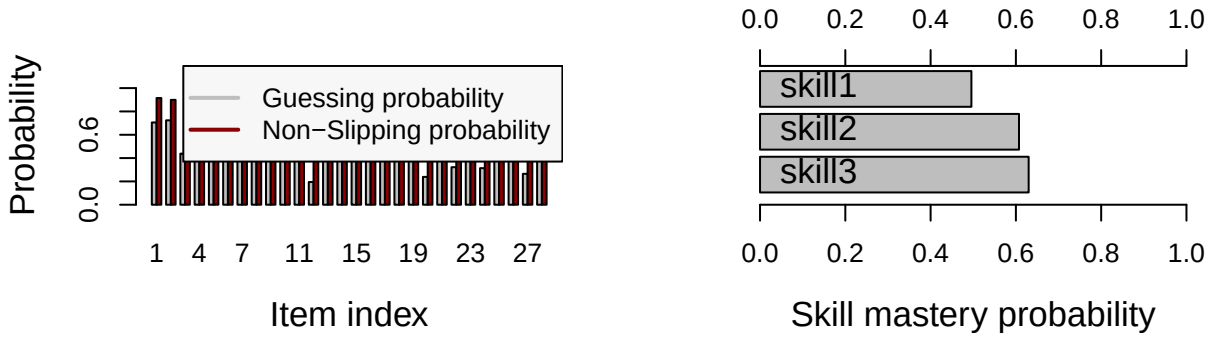
```
## 12  E12 0.195 0.305 0.500 0.026
## 13  E13 0.633 0.122 0.245 0.034
## 14  E14 0.517 0.212 0.272 0.023
## 15  E15 0.749 0.040 0.211 0.015
## 16  E16 0.549 0.126 0.325 0.038
## 17  E17 0.816 0.058 0.126 0.011
## 18  E18 0.729 0.086 0.185 0.010
## 19  E19 0.473 0.150 0.377 0.015
## 20  E20 0.239 0.295 0.466 0.026
## 21  E21 0.621 0.097 0.282 0.049
## 22  E22 0.322 0.188 0.490 0.024
## 23  E23 0.637 0.075 0.288 0.011
## 24  E24 0.313 0.322 0.365 0.021
## 25  E25 0.512 0.272 0.217 0.018
## 26  E26 0.555 0.211 0.234 0.015
## 27  E27 0.265 0.369 0.366 0.006
## 28  E28 0.659 0.086 0.255 0.011
##
## Marginal skill probabilities:
##        skill.prob
## skill1     0.4957
## skill2     0.6073
## skill3     0.6300
##
## Tetrachoric correlations among skill dimensions
##        skill1 skill2 skill3
## skill1 1.0000 0.8885 0.9154
## skill2 0.8885 1.0000 0.9139
## skill3 0.9154 0.9139 1.0000
##
## Skill Pattern Probabilities
##
##     000     100     010     001     110     101     011     111
## 0.31107 0.00613 0.04034 0.04958 0.01247 0.02589 0.10333 0.45120
```

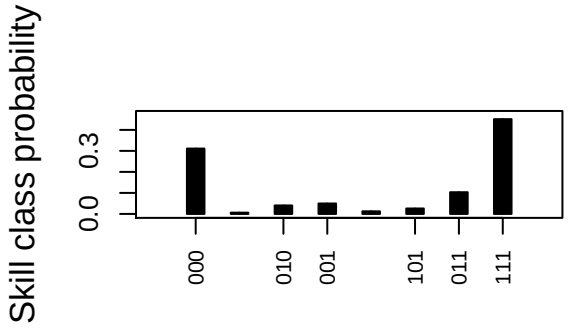
```
print(ecpe.dina)
```

```
## Estimation of Mixed DINA/DINO Model
##
## CDM 7.2-30 (2019-02-08 11:13:48)
##
## Call:
## din(data = data.ecpe$data[, -1], q.matrix = data.ecpe$q.matrix,
##     progress = FALSE)
##
## Number of cases=2922
## Number of items=28
## Number of skill dimensions=3
## Number of skill classes=8
## Number of parameters=63
##   # item parameters=56
##   # skill distribution parameters=7
##
## Log-Likelihood=-42843.46
## AIC=85813
```

```
## BIC=86190
```

```
par(mfrow=c(2,2))
plot(ecpe.dina)
```






```
# parameters and standard errors of DINA model
param <- IRT.se(ecpe.dina, extended=TRUE)
p <- split(param, param$partype)
p
```

```
## $guess
##    partype parindex parameter       est         se     2.5 %    97.5 %
## 1    guess        1  E1_guess 0.7053341 0.01256021 0.6807166 0.7299517
## 3    guess        3  E2_guess 0.7238056 0.01557211 0.6932849 0.7543264
## 5    guess        5  E3_guess 0.4381031 0.01380687 0.4110421 0.4651640
## 7    guess        7  E4_guess 0.4804197 0.01738231 0.4463510 0.5144884
## 9    guess        9  E5_guess 0.7636764 0.01391434 0.7364048 0.7909480
## 11   guess       11  E6_guess 0.7173405 0.01507642 0.6877912 0.7468897
## 13   guess       13  E7_guess 0.5438179 0.01399755 0.5163833 0.5712526
## 15   guess       15  E8_guess 0.8017958 0.01345476 0.7754249 0.8281666
## 17   guess       17  E9_guess 0.5343676 0.01714521 0.5007636 0.5679716
## 19   guess       19 E10_guess 0.4827295 0.01443041 0.4544465 0.5110126
## 21   guess       21 E11_guess 0.5562213 0.01372773 0.5293154 0.5831271
## 23   guess       23 E12_guess 0.1946139 0.01167786 0.1717258 0.2175021
## 25   guess       25 E13_guess 0.6330542 0.01365902 0.6062831 0.6598254
## 27   guess       27 E14_guess 0.5166922 0.01427147 0.4887207 0.5446638
## 29   guess       29 E15_guess 0.7489095 0.01441244 0.7206616 0.7771573
## 31   guess       31 E16_guess 0.5492260 0.01391425 0.5219546 0.5764975
## 33   guess       33 E17_guess 0.8155547 0.01200980 0.7920159 0.8390934
## 35   guess       35 E18_guess 0.7293164 0.01488188 0.7001485 0.7584844
## 37   guess       37 E19_guess 0.4732080 0.01759947 0.4387137 0.5077023
## 39   guess       39 E20_guess 0.2388085 0.01232369 0.2146545 0.2629625
```

```
## 41   guess       41 E21_guess 0.6214631 0.01346624 0.5950698 0.6478564
## 43   guess       43 E22_guess 0.3217567 0.01702903 0.2883804 0.3551330
## 45   guess       45 E23_guess 0.6370685 0.01691710 0.6039116 0.6702254
## 47   guess       47 E24_guess 0.3134852 0.01769723 0.2787993 0.3481712
## 49   guess       49 E25_guess 0.5117201 0.01427662 0.4837384 0.5397017
## 51   guess       51 E26_guess 0.5549666 0.01703229 0.5215839 0.5883493
## 53   guess       53 E27_guess 0.2650583 0.01303236 0.2395154 0.2906013
## 55   guess       55 E28_guess 0.6591149 0.01621625 0.6273317 0.6908982
##    item item.name skillclass fixed free rule totindex
## 1     1        E1          0 FALSE TRUE DINA        1
## 3     2        E2          0 FALSE TRUE DINA        3
## 5     3        E3          0 FALSE TRUE DINA        5
## 7     4        E4          0 FALSE TRUE DINA        7
## 9     5        E5          0 FALSE TRUE DINA        9
## 11    6        E6          0 FALSE TRUE DINA       11
## 13    7        E7          0 FALSE TRUE DINA       13
## 15    8        E8          0 FALSE TRUE DINA       15
## 17    9        E9          0 FALSE TRUE DINA       17
## 19   10       E10          0 FALSE TRUE DINA       19
## 21   11       E11          0 FALSE TRUE DINA       21
## 23   12       E12          0 FALSE TRUE DINA       23
## 25   13       E13          0 FALSE TRUE DINA       25
## 27   14       E14          0 FALSE TRUE DINA       27
## 29   15       E15          0 FALSE TRUE DINA       29
## 31   16       E16          0 FALSE TRUE DINA       31
## 33   17       E17          0 FALSE TRUE DINA       33
## 35   18       E18          0 FALSE TRUE DINA       35
## 37   19       E19          0 FALSE TRUE DINA       37
## 39   20       E20          0 FALSE TRUE DINA       39
## 41   21       E21          0 FALSE TRUE DINA       41
## 43   22       E22          0 FALSE TRUE DINA       43
## 45   23       E23          0 FALSE TRUE DINA       45
## 47   24       E24          0 FALSE TRUE DINA       47
## 49   25       E25          0 FALSE TRUE DINA       49
## 51   26       E26          0 FALSE TRUE DINA       51
## 53   27       E27          0 FALSE TRUE DINA       53
## 55   28       E28          0 FALSE TRUE DINA       55
##
## $margprobs
##      partype parindex   parameter       est         se     2.5 %    97.5 %
## 65 margprobs        0 prob_skill1 0.4956833 0.01557964 0.4651478 0.5262188
## 66 margprobs        0 prob_skill2 0.6073307 0.01668174 0.5746351 0.6400263
## 67 margprobs        0 prob_skill3 0.6299841 0.01297524 0.6045531 0.6554151
##    item item.name skillclass fixed  free rule totindex
## 65    0                    0 FALSE FALSE            65
## 66    0                    0 FALSE FALSE            66
## 67    0                    0 FALSE FALSE            67
##
## $probs
##    partype parindex   parameter         est          se        2.5 %
## 57   probs       57 prob_class1 0.311074178 0.016615891  0.278507630
## 58   probs       58 prob_class2 0.006133434 0.008651352 -0.010822903
## 59   probs       59 prob_class3 0.040339807 0.012668820  0.015509376
## 60   probs       60 prob_class4 0.049576658 0.010517344  0.028963042
```

```
## 61   probs       61 prob_class5 0.012468516 0.007852105 -0.002921327
## 62   probs       62 prob_class6 0.025885034 0.007090650  0.011987615
## 63   probs       63 prob_class7 0.103326045 0.011238043  0.081299885
## 64   probs        0 prob_class8 0.451196328 0.015248987  0.421308863
##        97.5 % item item.name skillclass fixed  free rule totindex
## 57 0.34364073    0                    1 FALSE  TRUE            57
## 58 0.02308977    0                    2 FALSE  TRUE            58
## 59 0.06517024    0                    3 FALSE  TRUE            59
## 60 0.07019027    0                    4 FALSE  TRUE            60
## 61 0.02785836    0                    5 FALSE  TRUE            61
## 62 0.03978245    0                    6 FALSE  TRUE            62
## 63 0.12535221    0                    7 FALSE  TRUE            63
## 64 0.48108379    0                    8 FALSE FALSE            64
##
## $slip
##    partype parindex parameter        est          se      2.5 %     97.5 %
## 2     slip        2   E1_slip 0.08503517 0.009349528 0.06671043 0.10335990
## 4     slip        4   E2_slip 0.10092311 0.008886350 0.08350618 0.11834004
## 6     slip        6   E3_slip 0.26573233 0.013341317 0.23958383 0.29188084
## 8     slip        8   E4_slip 0.16201356 0.009833474 0.14274030 0.18128681
## 10    slip       10   E5_slip 0.04046587 0.005295011 0.03008784 0.05084390
## 12    slip       12   E6_slip 0.06648817 0.006745318 0.05326759 0.07970875
## 14    slip       14   E7_slip 0.08462383 0.009047344 0.06689136 0.10235630
## 16    slip       16   E8_slip 0.03977443 0.006163573 0.02769404 0.05185481
## 18    slip       18   E9_slip 0.19913180 0.010528718 0.17849589 0.21976771
## 20    slip       20  E10_slip 0.16276272 0.011378382 0.14046150 0.18506394
## 22    slip       22  E11_slip 0.09893619 0.009481677 0.08035244 0.11751993
## 24    slip       24  E12_slip 0.30515493 0.014057252 0.27760322 0.33270663
## 26    slip       26  E13_slip 0.12169667 0.009910174 0.10227309 0.14112026
## 28    slip       28  E14_slip 0.21181583 0.012272701 0.18776178 0.23586989
## 30    slip       30  E15_slip 0.03994119 0.005382480 0.02939172 0.05049066
## 32    slip       32  E16_slip 0.12570135 0.010455328 0.10520929 0.14619342
## 34    slip       34  E17_slip 0.05795799 0.007078148 0.04408508 0.07183090
## 36    slip       36  E18_slip 0.08601661 0.007365173 0.07158114 0.10045209
## 38    slip       38  E19_slip 0.15017251 0.009597655 0.13136145 0.16898357
## 40    slip       40  E20_slip 0.29549079 0.013927080 0.26819422 0.32278737
## 42    slip       42  E21_slip 0.09655996 0.009180179 0.07856714 0.11455278
## 44    slip       44  E22_slip 0.18779334 0.010552648 0.16711053 0.20847615
## 46    slip       46  E23_slip 0.07527230 0.008456843 0.05869719 0.09184740
## 48    slip       48  E24_slip 0.32193191 0.013412625 0.29564364 0.34822017
## 50    slip       50  E25_slip 0.27165688 0.013371752 0.24544873 0.29786503
## 52    slip       52  E26_slip 0.21068721 0.010515228 0.19007775 0.23129668
## 54    slip       54  E27_slip 0.36867236 0.014472118 0.34030753 0.39703719
## 56    slip       56  E28_slip 0.08607046 0.007426670 0.07151445 0.10062646
##    item item.name skillclass fixed free rule totindex
## 2     1        E1          0 FALSE TRUE DINA        2
## 4     2        E2          0 FALSE TRUE DINA        4
## 6     3        E3          0 FALSE TRUE DINA        6
## 8     4        E4          0 FALSE TRUE DINA        8
## 10    5        E5          0 FALSE TRUE DINA       10
## 12    6        E6          0 FALSE TRUE DINA       12
## 14    7        E7          0 FALSE TRUE DINA       14
## 16    8        E8          0 FALSE TRUE DINA       16
## 18    9        E9          0 FALSE TRUE DINA       18
```

```
## 20   10       E10          0 FALSE TRUE DINA       20
## 22   11       E11          0 FALSE TRUE DINA       22
## 24   12       E12          0 FALSE TRUE DINA       24
## 26   13       E13          0 FALSE TRUE DINA       26
## 28   14       E14          0 FALSE TRUE DINA       28
## 30   15       E15          0 FALSE TRUE DINA       30
## 32   16       E16          0 FALSE TRUE DINA       32
## 34   17       E17          0 FALSE TRUE DINA       34
## 36   18       E18          0 FALSE TRUE DINA       36
## 38   19       E19          0 FALSE TRUE DINA       38
## 40   20       E20          0 FALSE TRUE DINA       40
## 42   21       E21          0 FALSE TRUE DINA       42
## 44   22       E22          0 FALSE TRUE DINA       44
## 46   23       E23          0 FALSE TRUE DINA       46
## 48   24       E24          0 FALSE TRUE DINA       48
## 50   25       E25          0 FALSE TRUE DINA       50
## 52   26       E26          0 FALSE TRUE DINA       52
## 54   27       E27          0 FALSE TRUE DINA       54
## 56   28       E28          0 FALSE TRUE DINA       56
```

```
# items characteristics (cf. Table 6)
pvalues <- colMeans(data.ecpe$data[,-1], na.rm=TRUE) # item p-values
p$guess # guessing parameters
```

```
##    partype parindex parameter       est         se     2.5 %    97.5 %
## 1    guess        1  E1_guess 0.7053341 0.01256021 0.6807166 0.7299517
## 3    guess        3  E2_guess 0.7238056 0.01557211 0.6932849 0.7543264
## 5    guess        5  E3_guess 0.4381031 0.01380687 0.4110421 0.4651640
## 7    guess        7  E4_guess 0.4804197 0.01738231 0.4463510 0.5144884
## 9    guess        9  E5_guess 0.7636764 0.01391434 0.7364048 0.7909480
## 11   guess       11  E6_guess 0.7173405 0.01507642 0.6877912 0.7468897
## 13   guess       13  E7_guess 0.5438179 0.01399755 0.5163833 0.5712526
## 15   guess       15  E8_guess 0.8017958 0.01345476 0.7754249 0.8281666
## 17   guess       17  E9_guess 0.5343676 0.01714521 0.5007636 0.5679716
## 19   guess       19 E10_guess 0.4827295 0.01443041 0.4544465 0.5110126
## 21   guess       21 E11_guess 0.5562213 0.01372773 0.5293154 0.5831271
## 23   guess       23 E12_guess 0.1946139 0.01167786 0.1717258 0.2175021
## 25   guess       25 E13_guess 0.6330542 0.01365902 0.6062831 0.6598254
## 27   guess       27 E14_guess 0.5166922 0.01427147 0.4887207 0.5446638
## 29   guess       29 E15_guess 0.7489095 0.01441244 0.7206616 0.7771573
## 31   guess       31 E16_guess 0.5492260 0.01391425 0.5219546 0.5764975
## 33   guess       33 E17_guess 0.8155547 0.01200980 0.7920159 0.8390934
## 35   guess       35 E18_guess 0.7293164 0.01488188 0.7001485 0.7584844
## 37   guess       37 E19_guess 0.4732080 0.01759947 0.4387137 0.5077023
## 39   guess       39 E20_guess 0.2388085 0.01232369 0.2146545 0.2629625
## 41   guess       41 E21_guess 0.6214631 0.01346624 0.5950698 0.6478564
## 43   guess       43 E22_guess 0.3217567 0.01702903 0.2883804 0.3551330
## 45   guess       45 E23_guess 0.6370685 0.01691710 0.6039116 0.6702254
## 47   guess       47 E24_guess 0.3134852 0.01769723 0.2787993 0.3481712
## 49   guess       49 E25_guess 0.5117201 0.01427662 0.4837384 0.5397017
## 51   guess       51 E26_guess 0.5549666 0.01703229 0.5215839 0.5883493
## 53   guess       53 E27_guess 0.2650583 0.01303236 0.2395154 0.2906013
## 55   guess       55 E28_guess 0.6591149 0.01621625 0.6273317 0.6908982
##    item item.name skillclass fixed free rule totindex
## 1     1        E1          0 FALSE TRUE DINA        1
```

```
## 3     2        E2          0 FALSE TRUE DINA        3
## 5     3        E3          0 FALSE TRUE DINA        5
## 7     4        E4          0 FALSE TRUE DINA        7
## 9     5        E5          0 FALSE TRUE DINA        9
## 11    6        E6          0 FALSE TRUE DINA       11
## 13    7        E7          0 FALSE TRUE DINA       13
## 15    8        E8          0 FALSE TRUE DINA       15
## 17    9        E9          0 FALSE TRUE DINA       17
## 19   10       E10          0 FALSE TRUE DINA       19
## 21   11       E11          0 FALSE TRUE DINA       21
## 23   12       E12          0 FALSE TRUE DINA       23
## 25   13       E13          0 FALSE TRUE DINA       25
## 27   14       E14          0 FALSE TRUE DINA       27
## 29   15       E15          0 FALSE TRUE DINA       29
## 31   16       E16          0 FALSE TRUE DINA       31
## 33   17       E17          0 FALSE TRUE DINA       33
## 35   18       E18          0 FALSE TRUE DINA       35
## 37   19       E19          0 FALSE TRUE DINA       37
## 39   20       E20          0 FALSE TRUE DINA       39
## 41   21       E21          0 FALSE TRUE DINA       41
## 43   22       E22          0 FALSE TRUE DINA       43
## 45   23       E23          0 FALSE TRUE DINA       45
## 47   24       E24          0 FALSE TRUE DINA       47
## 49   25       E25          0 FALSE TRUE DINA       49
## 51   26       E26          0 FALSE TRUE DINA       51
## 53   27       E27          0 FALSE TRUE DINA       53
## 55   28       E28          0 FALSE TRUE DINA       55
```

```
p$slip # slipping parameters
```

```
##    partype parindex parameter        est          se      2.5 %     97.5 %
## 2     slip        2   E1_slip 0.08503517 0.009349528 0.06671043 0.10335990
## 4     slip        4   E2_slip 0.10092311 0.008886350 0.08350618 0.11834004
## 6     slip        6   E3_slip 0.26573233 0.013341317 0.23958383 0.29188084
## 8     slip        8   E4_slip 0.16201356 0.009833474 0.14274030 0.18128681
## 10    slip       10   E5_slip 0.04046587 0.005295011 0.03008784 0.05084390
## 12    slip       12   E6_slip 0.06648817 0.006745318 0.05326759 0.07970875
## 14    slip       14   E7_slip 0.08462383 0.009047344 0.06689136 0.10235630
## 16    slip       16   E8_slip 0.03977443 0.006163573 0.02769404 0.05185481
## 18    slip       18   E9_slip 0.19913180 0.010528718 0.17849589 0.21976771
## 20    slip       20  E10_slip 0.16276272 0.011378382 0.14046150 0.18506394
## 22    slip       22  E11_slip 0.09893619 0.009481677 0.08035244 0.11751993
## 24    slip       24  E12_slip 0.30515493 0.014057252 0.27760322 0.33270663
## 26    slip       26  E13_slip 0.12169667 0.009910174 0.10227309 0.14112026
## 28    slip       28  E14_slip 0.21181583 0.012272701 0.18776178 0.23586989
## 30    slip       30  E15_slip 0.03994119 0.005382480 0.02939172 0.05049066
## 32    slip       32  E16_slip 0.12570135 0.010455328 0.10520929 0.14619342
## 34    slip       34  E17_slip 0.05795799 0.007078148 0.04408508 0.07183090
## 36    slip       36  E18_slip 0.08601661 0.007365173 0.07158114 0.10045209
## 38    slip       38  E19_slip 0.15017251 0.009597655 0.13136145 0.16898357
## 40    slip       40  E20_slip 0.29549079 0.013927080 0.26819422 0.32278737
## 42    slip       42  E21_slip 0.09655996 0.009180179 0.07856714 0.11455278
## 44    slip       44  E22_slip 0.18779334 0.010552648 0.16711053 0.20847615
## 46    slip       46  E23_slip 0.07527230 0.008456843 0.05869719 0.09184740
## 48    slip       48  E24_slip 0.32193191 0.013412625 0.29564364 0.34822017
```

```
## 50    slip       50  E25_slip 0.27165688 0.013371752 0.24544873 0.29786503
## 52    slip       52  E26_slip 0.21068721 0.010515228 0.19007775 0.23129668
## 54    slip       54  E27_slip 0.36867236 0.014472118 0.34030753 0.39703719
## 56    slip       56  E28_slip 0.08607046 0.007426670 0.07151445 0.10062646
##    item item.name skillclass fixed free rule totindex
## 2     1        E1          0 FALSE TRUE DINA        2
## 4     2        E2          0 FALSE TRUE DINA        4
## 6     3        E3          0 FALSE TRUE DINA        6
## 8     4        E4          0 FALSE TRUE DINA        8
## 10    5        E5          0 FALSE TRUE DINA       10
## 12    6        E6          0 FALSE TRUE DINA       12
## 14    7        E7          0 FALSE TRUE DINA       14
## 16    8        E8          0 FALSE TRUE DINA       16
## 18    9        E9          0 FALSE TRUE DINA       18
## 20   10       E10          0 FALSE TRUE DINA       20
## 22   11       E11          0 FALSE TRUE DINA       22
## 24   12       E12          0 FALSE TRUE DINA       24
## 26   13       E13          0 FALSE TRUE DINA       26
## 28   14       E14          0 FALSE TRUE DINA       28
## 30   15       E15          0 FALSE TRUE DINA       30
## 32   16       E16          0 FALSE TRUE DINA       32
## 34   17       E17          0 FALSE TRUE DINA       34
## 36   18       E18          0 FALSE TRUE DINA       36
## 38   19       E19          0 FALSE TRUE DINA       38
## 40   20       E20          0 FALSE TRUE DINA       40
## 42   21       E21          0 FALSE TRUE DINA       42
## 44   22       E22          0 FALSE TRUE DINA       44
## 46   23       E23          0 FALSE TRUE DINA       46
## 48   24       E24          0 FALSE TRUE DINA       48
## 50   25       E25          0 FALSE TRUE DINA       50
## 52   26       E26          0 FALSE TRUE DINA       52
## 54   27       E27          0 FALSE TRUE DINA       54
## 56   28       E28          0 FALSE TRUE DINA       56
```

```
omega1 <- 1 - p$guess$est - p$slip$est # item discrimination
omega2 <- (p$guess$est + (1 - p$slip$est))/2 # item easiness
```

```
# skill characteristics (cf. Table 7 and 8)
p$margprobs # skill distribution Q1
```

```
##      partype parindex   parameter       est         se     2.5 %    97.5 %
## 65 margprobs        0 prob_skill1 0.4956833 0.01557964 0.4651478 0.5262188
## 66 margprobs        0 prob_skill2 0.6073307 0.01668174 0.5746351 0.6400263
## 67 margprobs        0 prob_skill3 0.6299841 0.01297524 0.6045531 0.6554151
##    item item.name skillclass fixed  free rule totindex
## 65    0                    0 FALSE FALSE            65
## 66    0                    0 FALSE FALSE            66
## 67    0                    0 FALSE FALSE            67
```

```
p$probs # skill class distribution Q2
```

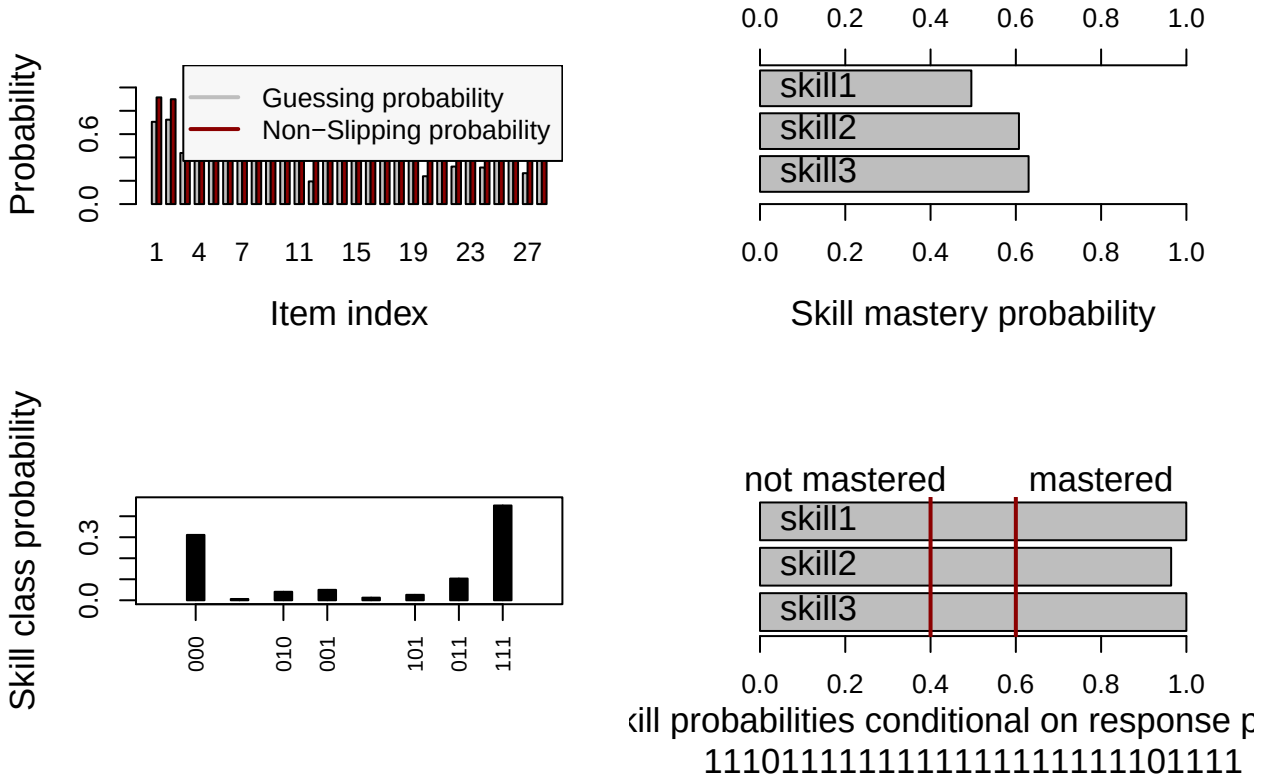
```
##    partype parindex   parameter         est          se        2.5 %
## 57   probs       57 prob_class1 0.311074178 0.016615891  0.278507630
## 58   probs       58 prob_class2 0.006133434 0.008651352 -0.010822903
## 59   probs       59 prob_class3 0.040339807 0.012668820  0.015509376
## 60   probs       60 prob_class4 0.049576658 0.010517344  0.028963042
```

```
## 61   probs       61 prob_class5 0.012468516 0.007852105 -0.002921327
## 62   probs       62 prob_class6 0.025885034 0.007090650  0.011987615
## 63   probs       63 prob_class7 0.103326045 0.011238043  0.081299885
## 64   probs        0 prob_class8 0.451196328 0.015248987  0.421308863
##        97.5 % item item.name skillclass fixed  free rule totindex
## 57 0.34364073    0                    1 FALSE  TRUE            57
## 58 0.02308977    0                    2 FALSE  TRUE            58
## 59 0.06517024    0                    3 FALSE  TRUE            59
## 60 0.07019027    0                    4 FALSE  TRUE            60
## 61 0.02785836    0                    5 FALSE  TRUE            61
## 62 0.03978245    0                    6 FALSE  TRUE            62
## 63 0.12535221    0                    7 FALSE  TRUE            63
## 64 0.48108379    0                    8 FALSE FALSE            64
```

```
IRT.factor.scores(ecpe.dina, type="MLE")[1:5,] # individual skill profile Q3
```

```
##      MLE.skill1 MLE.skill2 MLE.skill3
## [1,]          1          1          1
## [2,]          1          0          1
## [3,]          1          1          1
## [4,]          1          1          1
## [5,]          1          1          1
```

```
# plot model parameters
par(mfrow=c(2,2))
plot(ecpe.dina, pattern=data.ecpe$data[1,-1])
```




```
# correlation between skills
skill.cor(ecpe.dina)$cor.skills
```

```
##           skill1    skill2    skill3
```

```
## skill1 1.0000000 0.8884550 0.9153769
## skill2 0.8884550 1.0000000 0.9139451
## skill3 0.9153769 0.9139451 1.0000000
```

```r
# various fit criteria
fit.ecpe <- IRT.modelfit(ecpe.dina)
```

```r
# new Q-matrices
newq13 <- newq23 <- data.ecpe$q.matrix
newq13[,4] <- 1*(newq13[,1]==1 | newq13[,3]==1)
newq23[,4] <- 1*(newq23[,2]==1 | newq23[,3]==1)
newq13 <- newq13[,c(2,4)]
newq23 <- newq23[,c(1,4)]
```

```r
# define, estimate and derive model fit of competing models
ecpe13 <- din(data.ecpe$data[,-1], newq13)
```

```
## ------------------------------------------------------------------------------------
## DINA MODEL
## ** 2019-03-19 21:36:13
## ------------------------------------------------------------------------------------
## Iter.  1  :  21:36:13 ,   loglike= -49087.88  / max. param. ch. :  0.555764  / relative deviance char
## Iter.  2  :  21:36:13 ,   loglike= -43566.45  / max. param. ch. :  0.062705  / relative deviance char
## Iter.  3  :  21:36:13 ,   loglike= -43378.28  / max. param. ch. :  0.041928  / relative deviance char
## Iter.  4  :  21:36:13 ,   loglike= -43257.83  / max. param. ch. :  0.032784  / relative deviance char
## Iter.  5  :  21:36:13 ,   loglike= -43174.65  / max. param. ch. :  0.029079  / relative deviance char
## Iter.  6  :  21:36:13 ,   loglike= -43116.1  / max. param. ch. :  0.025351  / relative deviance chang
## Iter.  7  :  21:36:13 ,   loglike= -43074.3  / max. param. ch. :  0.021922  / relative deviance chang
## Iter.  8  :  21:36:13 ,   loglike= -43044.19  / max. param. ch. :  0.018845  / relative deviance char
## Iter.  9  :  21:36:13 ,   loglike= -43022.4  / max. param. ch. :  0.016488  / relative deviance chang
## Iter.  10  :  21:36:13 ,   loglike= -43006.58  / max. param. ch. :  0.014918  / relative deviance cha
## Iter.  11  :  21:36:13 ,   loglike= -42995.09  / max. param. ch. :  0.013455  / relative deviance cha
## Iter.  12  :  21:36:13 ,   loglike= -42986.72  / max. param. ch. :  0.012107  / relative deviance cha
## Iter.  13  :  21:36:13 ,   loglike= -42980.6  / max. param. ch. :  0.010878  / relative deviance char
## Iter.  14  :  21:36:13 ,   loglike= -42976.09  / max. param. ch. :  0.009766  / relative deviance cha
## Iter.  15  :  21:36:13 ,   loglike= -42972.74  / max. param. ch. :  0.008767  / relative deviance cha
## Iter.  16  :  21:36:13 ,   loglike= -42970.21  / max. param. ch. :  0.007876  / relative deviance cha
## Iter.  17  :  21:36:13 ,   loglike= -42968.28  / max. param. ch. :  0.007082  / relative deviance cha
## Iter.  18  :  21:36:13 ,   loglike= -42966.79  / max. param. ch. :  0.006378  / relative deviance cha
## Iter.  19  :  21:36:13 ,   loglike= -42965.6  / max. param. ch. :  0.005756  / relative deviance char
## Iter.  20  :  21:36:13 ,   loglike= -42964.65  / max. param. ch. :  0.005205  / relative deviance cha
## Iter.  21  :  21:36:13 ,   loglike= -42963.87  / max. param. ch. :  0.004719  / relative deviance cha
## Iter.  22  :  21:36:13 ,   loglike= -42963.21  / max. param. ch. :  0.004289  / relative deviance cha
## Iter.  23  :  21:36:13 ,   loglike= -42962.66  / max. param. ch. :  0.00391  / relative deviance char
## Iter.  24  :  21:36:13 ,   loglike= -42962.18  / max. param. ch. :  0.003574  / relative deviance cha
## Iter.  25  :  21:36:13 ,   loglike= -42961.76  / max. param. ch. :  0.003277  / relative deviance cha
## Iter.  26  :  21:36:13 ,   loglike= -42961.4  / max. param. ch. :  0.003013  / relative deviance char
## Iter.  27  :  21:36:13 ,   loglike= -42961.07  / max. param. ch. :  0.002778  / relative deviance cha
## Iter.  28  :  21:36:13 ,   loglike= -42960.78  / max. param. ch. :  0.00257  / relative deviance char
## Iter.  29  :  21:36:13 ,   loglike= -42960.51  / max. param. ch. :  0.002383  / relative deviance cha
## Iter.  30  :  21:36:13 ,   loglike= -42960.27  / max. param. ch. :  0.002216  / relative deviance cha
## Iter.  31  :  21:36:13 ,   loglike= -42960.05  / max. param. ch. :  0.002067  / relative deviance cha
## Iter.  32  :  21:36:13 ,   loglike= -42959.85  / max. param. ch. :  0.001932  / relative deviance cha
## Iter.  33  :  21:36:13 ,   loglike= -42959.66  / max. param. ch. :  0.00181  / relative deviance char
## Iter.  34  :  21:36:13 ,   loglike= -42959.49  / max. param. ch. :  0.0017  / relative deviance chang
```

```
## Iter.  35  :  21:36:13 ,   loglike= -42959.34  / max. param. ch. :  0.0016  / relative deviance chang
## Iter.  36  :  21:36:13 ,   loglike= -42959.19  / max. param. ch. :  0.001509  / relative deviance cha
## Iter.  37  :  21:36:13 ,   loglike= -42959.06  / max. param. ch. :  0.001426  / relative deviance cha
## Iter.  38  :  21:36:13 ,   loglike= -42958.93  / max. param. ch. :  0.00135  / relative deviance char
## Iter.  39  :  21:36:13 ,   loglike= -42958.82  / max. param. ch. :  0.001281  / relative deviance cha
## Iter.  40  :  21:36:13 ,   loglike= -42958.71  / max. param. ch. :  0.001216  / relative deviance cha
## Iter.  41  :  21:36:13 ,   loglike= -42958.61  / max. param. ch. :  0.001157  / relative deviance cha
## Iter.  42  :  21:36:13 ,   loglike= -42958.52  / max. param. ch. :  0.001104  / relative deviance cha
## Iter.  43  :  21:36:13 ,   loglike= -42958.44  / max. param. ch. :  0.001057  / relative deviance cha
## Iter.  44  :  21:36:13 ,   loglike= -42958.36  / max. param. ch. :  0.001014  / relative deviance cha
## Iter.  45  :  21:36:13 ,   loglike= -42958.28  / max. param. ch. :  0.000972  / relative deviance cha
## ------------------------------------------------------------------------------
## Time difference of 0.3290222 secs
```

```
fit.ecpe13 <- IRT.modelfit(ecpe13)
ecpe23 <- din(data.ecpe$data[,-1], newq23)
```

```
## ------------------------------------------------------------------------------
## DINA MODEL
## ** 2019-03-19 21:36:14
## ------------------------------------------------------------------------------
## Iter.  1  :  21:36:14 ,   loglike= -48109.74  / max. param. ch. :  0.487379  / relative deviance char
## Iter.  2  :  21:36:14 ,   loglike= -43502.07  / max. param. ch. :  0.081658  / relative deviance char
## Iter.  3  :  21:36:14 ,   loglike= -43278.9  / max. param. ch. :  0.053057  / relative deviance chang
## Iter.  4  :  21:36:14 ,   loglike= -43139.29  / max. param. ch. :  0.042789  / relative deviance char
## Iter.  5  :  21:36:14 ,   loglike= -43047.38  / max. param. ch. :  0.03384  / relative deviance chang
## Iter.  6  :  21:36:14 ,   loglike= -42986.64  / max. param. ch. :  0.02917  / relative deviance chang
## Iter.  7  :  21:36:14 ,   loglike= -42946.43  / max. param. ch. :  0.024762  / relative deviance char
## Iter.  8  :  21:36:14 ,   loglike= -42919.7  / max. param. ch. :  0.020861  / relative deviance chang
## Iter.  9  :  21:36:14 ,   loglike= -42901.86  / max. param. ch. :  0.017498  / relative deviance char
## Iter.  10  :  21:36:14 ,   loglike= -42889.91  / max. param. ch. :  0.014639  / relative deviance cha
## Iter.  11  :  21:36:14 ,   loglike= -42881.88  / max. param. ch. :  0.012229  / relative deviance cha
## Iter.  12  :  21:36:14 ,   loglike= -42876.46  / max. param. ch. :  0.01021  / relative deviance char
## Iter.  13  :  21:36:14 ,   loglike= -42872.78  / max. param. ch. :  0.008525  / relative deviance cha
## Iter.  14  :  21:36:14 ,   loglike= -42870.27  / max. param. ch. :  0.007122  / relative deviance cha
## Iter.  15  :  21:36:14 ,   loglike= -42868.54  / max. param. ch. :  0.005957  / relative deviance cha
## Iter.  16  :  21:36:14 ,   loglike= -42867.35  / max. param. ch. :  0.00499  / relative deviance char
## Iter.  17  :  21:36:14 ,   loglike= -42866.51  / max. param. ch. :  0.004188  / relative deviance cha
## Iter.  18  :  21:36:14 ,   loglike= -42865.91  / max. param. ch. :  0.003523  / relative deviance cha
## Iter.  19  :  21:36:14 ,   loglike= -42865.48  / max. param. ch. :  0.002971  / relative deviance cha
## Iter.  20  :  21:36:14 ,   loglike= -42865.17  / max. param. ch. :  0.002513  / relative deviance cha
## Iter.  21  :  21:36:14 ,   loglike= -42864.94  / max. param. ch. :  0.002133  / relative deviance cha
## Iter.  22  :  21:36:14 ,   loglike= -42864.76  / max. param. ch. :  0.001816  / relative deviance cha
## Iter.  23  :  21:36:14 ,   loglike= -42864.63  / max. param. ch. :  0.001553  / relative deviance cha
## Iter.  24  :  21:36:14 ,   loglike= -42864.52  / max. param. ch. :  0.001333  / relative deviance cha
## Iter.  25  :  21:36:14 ,   loglike= -42864.43  / max. param. ch. :  0.00115  / relative deviance char
## Iter.  26  :  21:36:14 ,   loglike= -42864.36  / max. param. ch. :  0.000996  / relative deviance cha
## ------------------------------------------------------------------------------
## Time difference of 0.282624 secs
```

```
fit.ecpe23 <- IRT.modelfit(ecpe23)
```

```
# compare competing models
IRT.compareModels(fit.ecpe, fit.ecpe13, fit.ecpe23)
```

```
## $IC
```

```
##       Model   loglike Deviance Npars Nobs      AIC      BIC     AIC3
## 1 ecpe.dina -42843.46 85686.92    63 2922 85812.92 86189.66 85875.92
## 2    ecpe13 -42958.28 85916.57    59 2922 86034.57 86387.39 86093.57
## 3    ecpe23 -42864.36 85728.73    59 2922 85846.73 86199.55 85905.73
##       AICc     CAIC    maxX2      p_maxX2     MADcor      SRMSR
## 1 85815.74 86252.66 26.49727 9.975836e-05 0.02698065 0.03335456
## 2 86037.04 86446.39 42.69816 2.414375e-08 0.02785730 0.03455443
## 3 85849.20 86258.55 28.15671 4.229026e-05 0.02753171 0.03381068
##   X100.MADRESIDCOV      MADQ3     MADaQ3
## 1        0.4859439 0.02188738 0.02188686
## 2        0.4935378 0.02277506 0.02215680
## 3        0.4931428 0.02229681 0.02224012
##
## $LRtest
##   Model1    Model2      Chi2 df            p
## 1 ecpe13 ecpe.dina 229.64775  4 0.000000e+00
## 2 ecpe23 ecpe.dina  41.80972  4 1.826733e-08
##
## attr(,"class")
## [1] "IRT.compareModels"
```