DINA model on ECPE Dataset

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 0 1 1 ...
##  $ E12: int  1 1 1 1 0 1 1 1 0 0 ...
##  $ E13: int  1 1 1 1 1 1 1 0 1 1 ...
##  $ E14: int  1 1 1 1 1 1 1 0 1 1 ...
##  $ E15: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E16: int  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 0 0 0 ...
##  $ E21: int  1 1 1 1 1 0 0 1 1 0 ...
##  $ E22: int  1 1 1 1 0 1 1 1 1 0 ...
##  $ E23: int  1 1 1 1 1 1 1 1 1 0 ...
##  $ E24: int  0 0 1 1 1 1 1 0 1 0 ...
##  $ E25: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E26: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ E27: int  1 1 1 1 1 1 1 0 1 1 ...
##  $ E28: int  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
```

```r
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 create separate copies of each type of parameter

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

Item characteristics

Item p-values

```
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

```
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

```
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
```

Summarizing DINA model

```
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: 2019-03-22 03:49:08
## Time difference of 0.4599388 secs
## Computation Time: 0.4599388
##
##
## 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
```

```r
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)
```