**Lab 3: Using R for Polytomous Item Response Models**

**Mar 1, 2023**

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| Outline   * ‘eRm’ R package for a rating scale model and a partial credit model. * ‘ltm’ R package for a generalized partial credit model * `mirt’ R package for a graded response model * Examples |

* Estimation

**1. Installation of R package ‘eRm’, ‘ltm’, and ‘mirt’**

[1] Packages > Install package(s) > USA(TN) > eRm

[2] Packages > Install package(s) > USA(TN) > ltm [When you have never installed ‘ltm’]

or

update.packages(ask='ltm',checkBuilt=TRUE) [When you already installed ‘ltm’]

[3] Packages > Install package(s) > USA(TN) > mirt

**2. Functions in the R package ‘eRm’ and ‘ltm’**

**[1] ‘eRm’**

Find the following functions of the ‘eRm’ manual downloaded from <http://cran.r-project.org/web/packages/eRm/eRm.pdf>:

* ‘RSM’ function [Estimation of rating scale model]
* ‘PCM’ function [Estimation of partial credit model]
* ‘person.parameter’ function [Estimation of person parameters]
* ‘plotICC’ function [ICC plots]
* ‘plotINFO’ function [Plot information for ‘eRm’ objects]
* ‘plotPImap’ function [Person-item map]
* ‘thresholds’ function [Computation of item-category threshold parameters]

Parameter estimation method is *conditional maximum likelihood estimation*, not *marginal maximum likelihood estimation*.

**[2] ‘ltm’**

Find the following functions of the ‘eRm’ manual downloaded from <http://cran.r-project.org/web/packages/ltm/ltm.pdf>:

* ‘gpcm’ function [Generalized partial credit model – polytomous IRT]
* ‘factor.scores’ function [Factor Scores – Ability Estimates]

**[3] ‘mirt’**

Find the following functions of the ‘mirt’ manual downloaded from <https://cran.r-project.org/web/packages/mirt/mirt.pdf>

* ‘mirt’ function
* ‘fscores’ function
* ‘itemplot’ function
* ‘plot’ function
* Example

**1. Dataset**

polytomous.txt

25-item, 316-person

Codes as 0, 1, or 2

Note: Missing responses can be coded as **NA**.

**2. R Scripts and results**

**[1] Preparing for libraries and data**

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| Script |
| ## Updating packages  update.packages(ask='eRm',checkBuilt=TRUE)  update.packages(ask='ltm',checkBuilt=TRUE)  ## Checking versions  packageVersion("eRm")  packageVersion("ltm")  ## Call libraries irtoys and ltem  library(eRm)  library(ltm)  ## Importing polytomous data (polytomous.txt)  poly <- read.table("C:/Teaching/IRT I\_2023 Spring/Labs/Lab 3/ polytomous.txt",header=TRUE)  poly[1:10,] # Checking the first 10 rows  poly[,1:10] # Checking the first 10 columns  poly[1:10,1:10] # Checking the first 10 rows and 10 columns |

**[2] Rating scale model using ‘eRm’**

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| Script |
| ## Fitting a rating scale model using 'eRm': Conditional MLE  # Item parameters  rsm <- RSM(poly, se = TRUE, sum0 = TRUE)  rsm    # Person parameters: MLE  rsm\_person <- person.parameter(rsm)  rsm\_person  summary(rsm\_person)  plot(rsm\_person)  # CCC  plotICC(rsm) # For all items  plotICC(rsm, item.subset=23:23) # Item 23  plotICC(rsm, item.subset=23:25) # Items 23, 24, and 25  thresholds(rsm)  # Item Information function  plotINFO(rsm, type="item")  # Test information function  plotINFO(rsm, type="test")  # Wright map  plotPImap(rsm, sorted=TRUE, warn.ord.colour=TRUE, irug=TRUE) |

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| Results |
| > plotINFO(rsm, type="test")  estimate = 0.5  > rsm <- RSM(poly, se = TRUE, sum0 = TRUE)  > rsm  Results of RSM estimation:  Call: RSM(X = poly, se = TRUE, sum0 = TRUE)  Conditional log-likelihood: -5720.688  Number of iterations: 33  Number of parameters: 25    Item (Category) Difficulty Parameters :  item2 item3 item4 item5 item6 item7  Estimate -0.03269591 0.4897401 -0.68452559 -0.55657194 -0.1744654 -0.86769558  Std.Err 0.08339512 0.0911244 0.08135627 0.08111524 0.0822506 0.08223139  item8 item9 item10 item11 item12 item13  Estimate 0.02532171 -0.14643780 -0.29213891 0.26762989 0.60472136 -0.83355651  Std.Err 0.08397852 0.08244537 0.08160056 0.08715012 0.09359705 0.08202137  item14 item15 item16 item17 item18  Estimate -0.36048625 -0.45542575 -0.89510388 -0.48243833 -0.003793187  Std.Err 0.08134656 0.08114292 0.08241541 0.08111649 0.083677447  item19 item20 item21 item22 item23 item24  Estimate 0.65998314 1.163048 1.7424047 -0.04707178 0.58662567 1.0659514  Std.Err 0.09488935 0.109972 0.1358416 0.08326085 0.09318856 0.1065703  item25 Cat 2 ()  Estimate -0.22318145 0.50020325  Std.Err 0.08194871 0.05891826    > rsm\_person <- person.parameter(rsm)  > summary(rsm\_person)  Estimation of Ability Parameters  Collapsed log-likelihood: -922.8459  Number of iterations: 16  Number of parameters: 45  ML estimated ability parameters (without spline interpolated values):  Estimate Std. Err. 2.5 % 97.5 %  theta P1 -2.722493461 0.7053146 -4.10488475 -1.34010217  theta P2 -1.305802704 0.3687454 -2.02853050 -0.58307491  theta P3 -1.057572677 0.3376921 -1.71943696 -0.39570839  theta P4 -0.564613886 0.2958243 -1.14441878 0.01519101  …….  > plotICC(rsm, item.subset=23:23)  Press “Enter” key in R Graphics window.  Waiting to confirm page change...    I called ICC plot CCC (category characteristic curve) plot.  > thresholds(rsm)  Design Matrix Block 1:  Location Threshold 1 Threshold 2  item1 -0.29974 -0.54984 -0.04963  …  item23 0.83673 0.58663 1.08683  item24 1.31605 1.06595 1.56615  item25 0.02692 -0.22318 0.27702  > # Item Information function  > plotINFO(rsm, type="item")    > # Test information function  > plotINFO(rsm, type="test")    > # Wright map  > plotPImap(rsm, sorted=TRUE, warn.ord.colour=TRUE, irug=TRUE)    All thresholds are plotted below the person distribution to indicate where the included items are most informative. |

**[3] Partial credit model**

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| Script |
| ## Fitting a partial credit model using 'eRm': Conditional MLE  pcm <- PCM(poly, se = TRUE, sum0 = TRUE)  thresholds(pcm)  # Person parameters: MLE  pcm\_person <- person.parameter(pcm)  pcm\_person  summary(pcm\_person)  # CCC  plotICC(pcm) # For all items  plotICC(pcm, item.subset=23:23) # Item 23  plotICC(pcm, item.subset=23:25) # Items 23, 24, and 25  thresholds(pcm)  # Item & test Information functions  plotINFO(pcm)  # Wright map  plotPImap(pcm, sorted=TRUE) |

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| Results |
| > ## Fitting a partial credit model using 'eRm': Conditional MLE  > pcm <- PCM(poly, se = TRUE, sum0 = TRUE)  > thresholds(pcm)    Design Matrix Block 1:  Location  Threshold 1 () Threshold 2 ()  item1 -0.47012 -0.89474 -0.04550  item2 0.06467 -0.32129 0.45063  ….  item23 0.70805 0.31444 1.10166  item24 1.11674 0.93839 1.29509  item25 -0.10983 -0.69517 0.47551  > summary(pcm\_person)  Estimation of Ability Parameters  Collapsed log-likelihood: -920.6864  Number of iterations: 17  Number of parameters: 45  ML estimated ability parameters (without spline interpolated values):  Estimate Std. Err. 2.5 % 97.5 %  theta P1 -2.89776018 0.7060297 -4.28155306 -1.513967306  theta P2 -1.47847473 0.3688678 -2.20144229 -0.755507175  theta P3 -1.23017803 0.3376822 -1.89202301 -0.568333056  theta P4 -0.73751243 0.2956876 -1.31704957 -0.157975288  theta P5 -1.01700781 0.3164124 -1.63716474 -0.396850884  theta P6 -0.82661282 0.3014488 -1.41744155 -0.235784099  ……….. |

**[4] Generalized partial credit model**

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| Script |
| ## Fitting a generalized partial credit model using 'ltm': Marginal MLE  # Item parameters  gpcm <- gpcm(poly, IRT.param = TRUE)  summary(gpcm)  # Person parameters  gpcm\_person <- factor.scores(gpcm) |

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| Results |
| > ## Fitting a generalized partial credit model using 'ltm': Marginal MLE  > # Item parameters  > gpcm <- gpcm(poly, IRT.param = TRUE)  > summary(gpcm)  Call:  gpcm(data = poly, IRT.param = TRUE)  Model Summary:  log.Lik AIC BIC  -6832.259 13814.52 14096.2    Coefficients:  $item1  value std.err z.value  Catgr.1 () -0.380 0.155 -2.442  Catgr.2 () 0.480 0.162 2.967  Dscrmn () 1.018 0.141 7.227  $item2  value std.err z.value  Catgr.1 0.212 0.167 1.269  Catgr.2 0.994 0.196 5.071  Dscrmn 0.962 0.135 7.106  $item3  value std.err z.value  Catgr.1 1.491 0.366 4.068  Catgr.2 1.499 0.358 4.190  Dscrmn 0.602 0.109 5.499  $item4  value std.err z.value  Catgr.1 -0.152 0.146 -1.042  Catgr.2 -0.003 0.145 -0.021  Dscrmn 1.283 0.176 7.288  ….. |

**[5] Graded response model**

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| Script |
| ## Fitting a graded response model using 'mirt'  # Item parameters  grm <- mirt(poly, 1, itemtype='graded', method="EM", SE=TRUE)  coef.grm <-coef(grm, printSE=TRUE, as.data.frame=TRUE)  coef.grm  # Person parameters  theta<-fscores(grm, full.scores.SE=TRUE)  write.table(theta, file="C:/Teaching/IRT I\_2020 Spring/Labs/Lab 3/theta.txt", sep = "\t", row.names=F)  # CCC  itemplot(grm, 1) #CCC for item 1  # Item & test Information functions  itemplot(grm, 1, type = 'info') #item information for item 1  plot(grm, type = 'info') #test information for all items |

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| Results |
| > grm <- mirt(poly, 1, itemtype='graded', method="EM", SE=TRUE)  Iteration: 1, Log-Lik: -6900.826, Max-Change: 0.51849Iteration: 2, Log-Lik: -6826.564, Max-Change: 0.26239Iteration: 3, Log-Lik: -6810.218, Max-Change: 0.15743…  Calculating information matrix...  > coef.grm <-coef(grm, printSE=TRUE, as.data.frame=TRUE)  > coef.grm  par SE  item1.a1 1.426 0.208 [Item1’s item discrimination]  item1.d1 0.873 0.192 [Item1’s first GRM threshold]  item1.d2 -1.128 0.199 [Item1’s second GRM threshold]  …  item2.a1 1.305 0.227  item2.d1 0.127 0.185  item2.d2 -1.807 0.223  item3.a1 0.884 0.190  item3.d1 -0.576 0.179  item3.d2 -2.138 0.231  …  <theta[1:10,]  F1: IRT scale score for each person  SE\_F1: Standard error of the IRT score score  item22 item23 item24 item25 F1 SE\_F1  [1,] 0 0 0 0 -2.2484 0.5388  [2,] 0 0 0 1 -1.9501 0.4738  [3,] 0 0 0 2 -1.9131 0.4747  [4,] 1 0 0 0 -1.8768 0.4592  [5,] 0 0 0 0 -1.6961 0.4301  [6,] 0 0 0 0 -1.8480 0.4510  [7,] 0 0 0 0 -1.4980 0.4069  [8,] 0 0 0 0 -2.0055 0.4844  [9,] 0 0 0 0 -1.6765 0.4157  [10,] 0 0 0 0 -1.6212 0.4202  > # CCC  > itemplot(grm, 1) #CCC for item 1    Category characteristic curve (CCC) for Item 1.  Note that this CCC is the same as CCC from GPCM.  > # Item & test Information functions  > itemplot(grm, 1, type = 'info') #item information for item 1    Item information curve for Item 1.    Test information curve for Item 1. |