eat: An R Package for Automation of Data Preparation and IRT Modeling

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Overview

The Institute

- Independent research and test institute founded by the 16 federal states in 2004
- Nationwide Educational Standards Assessments in German, the first foreign language, Mathematics and Science which allow comparison of federal states ($N \approx 30,000$)
- Assessment tests in German, Mathematics and the first foreign language in the 8th grade at secondary school (once a year)
- Assessment tests in German and Mathematics in the 3rd grade at primary school (once a year)

ConQuest

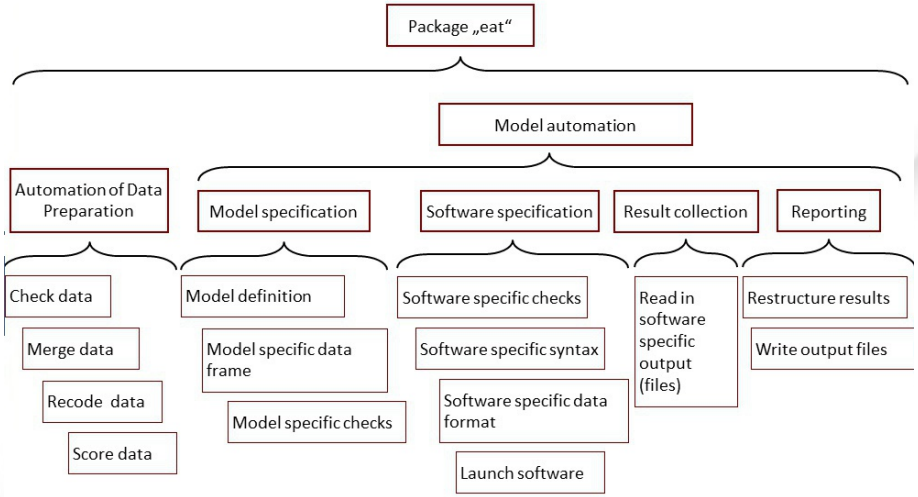
- Commercial Software developed by ACER (Wu, Adams & Wilson, 1997)
- Major scaling tool of the Organisation for Economic Co-operation and Development's Programme for International Student Assessment (PISA)
- Fits a large number of different item response models
  - Rasch, partial credit, rating scale, facets, ...
  - Latent regression
  - Multidimensionality
- Estimation
  - Marginal Maximum Likelihood
  - Gaussian quadrature/ Monte Carlo approximations
  - Person parameter estimation: EAP, MLE, WLE, Plausible values

Automation of Data Preparation and Analysis

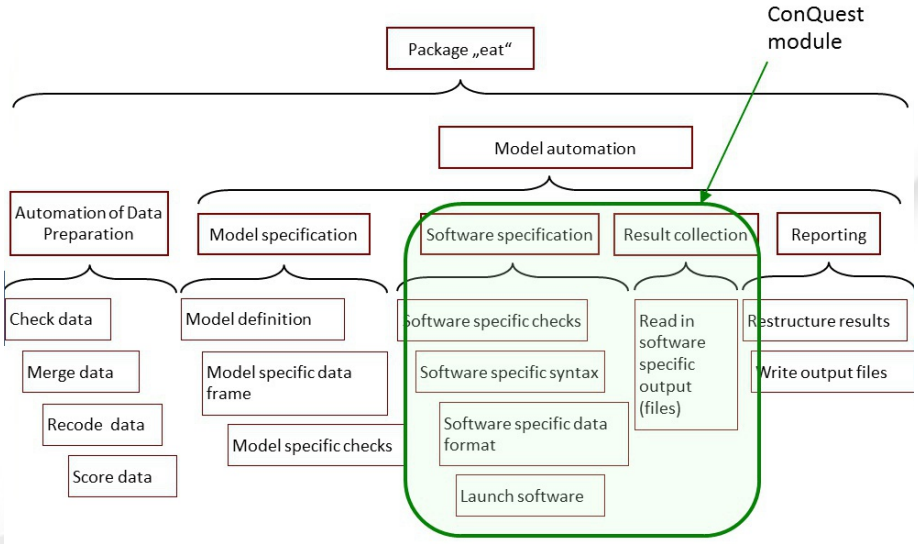
- automate data preparation
  1. read in & check SPSS-files
  2. merge data frames (booklets)
  3. recode & dichotomize data
- automate IRT calibration
  1. write ConQuest syntax, generate appropriate data input
  2. execute ConQuest
  3. read in ConQuest output
- facilitate reporting
  1. write out results (graphics, tables, ...)

⇒ "eat" ("Educational Assessment Tools")

Implemented Modules



Wrapping ConQuest



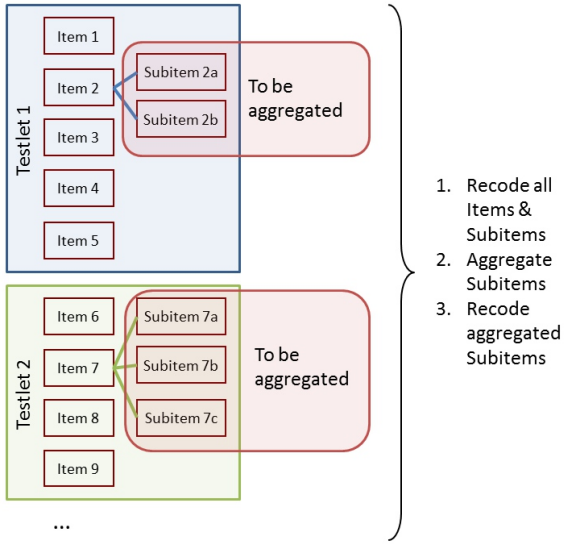
Typical Items

	0. Place to hire a bike	Cambridge Station
item 1	1. Standard equipment of all bikes (Name one.)	lights
item 2	2. Extras you can ask for	a)
		b)
item 3	3. Price for 4 hours	£ 6
item 4	4. Price for one month	£ 38
item 5	5. Students' offer for 2 weeks	£ 25

Typical Items - Scores

0. Place to hire a bike	Cambridge Station		
1. Standard equipment of all bikes (Name one.)	lights	3	1
2. Extras you can ask for	a)	9	mbi
	b)	9	mbi
3. Price for 4 hours	£ 6	0	0
4. Price for one month	£ 38	1	1
5. Students' offer for 2 weeks	£ 25	1	1
		Trained Rater	Recoded

Data Structure



automateDataPreparation

```
dataset <- automateDataPreparation ( inputList = inputList, path = path,
      loadSav = TRUE,
      checkData = TRUE,
      mergeData = TRUE,
      recodeData = TRUE,
      aggregateData = TRUE,
      scoreData = TRUE,
      writeSpss = TRUE )
```


Data Preparation Input

```
> inputList$units
      unit                    unitLabel unitType unitAggregateRule
1   ER52501                 Bikes ER52501       TI
2   ER52502                 Bikes ER52502       TI              SUM
3   ER52503                 Bikes ER52503       TI
4   ER52504                 Bikes ER52504       TI
5   ER52505                 Bikes ER52505       TI
> inputList$subunits
      unit  subunit                                subunitLabel subunitRecoded subunitLabelRecoded
1   ER52501  ER52501                 Bikes ER52501      ER52501R    Recoded ER52501
2   ER52502 ER52502a                Bikes ER52502a     ER52502aR   Recoded ER52502a
3   ER52502 ER52502b                Bikes ER52502b     ER52502bR   Recoded ER52502b
4   ER52503  ER52503                 Bikes ER52503      ER52503R    Recoded ER52503
5   ER52504  ER52504                 Bikes ER52504      ER52504R    Recoded ER52504
6   ER52505  ER52505                 Bikes ER52505      ER52505R    Recoded ER52505
> inputList$values
    subunit value valueRecode valueType              valueLabel
9  ER52502a     1           1        vc                   gloves
10 ER52502a     2           0        vc                    other
11 ER52502a     6         mnr       mnr       missing not reached
12 ER52502a     7         mci       mci missing coding impossible
13 ER52502a     8         mir       mir         invalid response
14 ER52502a     9         mbi       mbi      missing by intention
15 ER52502b     1           1        vc             water bottle
16 ER52502b     2           0        vc                    other
17 ER52502b     6         mnr       mnr       missing not reached
18 ER52502b     7         mci       mci missing coding impossible
19 ER52502b     8         mir       mir         invalid response
20 ER52502b     9         mbi       mbi      missing by intention
> inputList$unitRecodings
      unit value valueRecode valueType valueLabelRecoded
1   ER52502     0           0        vc          ER52502R
2   ER52502     1           0        vc          ER52502R
3   ER52502     2           1        vc          ER52502R
```

Data Preparation Logfile

```
--------------------------------------------------------------------------------------
| 2012-01-20 17:10:28 | USER212 | PC017 | R version 2.14.0 (2011-10-31) /i386 |
--------------------------------------------------------------------------------------
automateDataPreparation: Starting automateDataPreparation 2012-01-20 17:10:28

automateDataPreparation: Load .sav Files

automateDataPreparation: Check data...
.checkData.checkID: Only valid codes in ID variable.
.checkData.checkID: No duplicated entries in ID variable.
.checkData.checkVars: No duplicated variable names.
.checkData.checkCodes: Found no invalid codes.
.checkData.checkMissings: Case(s)23 contain(s) only missing values.

automateDataPreparation: Start merging
mergeData_0.4.0: Start merging of dataset 1.
mergeData_0.4.0: Start merging of dataset 2.
mergeData_0.4.0: Start merging of dataset 3.

automateDataPreparation: Start recoding
recodeData_1.0.1: ER52501 has been recoded.
recodeData_1.0.1: ER52502a has been recoded.
recodeData_1.0.1: ER52502b has been recoded.
recodeData_1.0.1: ER52503 has been recoded.
recodeData_1.0.1: ER52504 has been recoded.
recodeData_1.0.1: ER52505 has been recoded.

automateDataPreparation: Start aggregating
aggregateData_1.2.0: Aggregate unit ER52502.

automateDataPreparation: Start scoring
recodeData_1.0.1: ER52502 has been recoded.

automateDataPreparation: Writing dataset in last transformation status to disk
writeSpss_0.2.0:  Data values written to c:/temp/zkddata.txt
writeSpss_0.2.0:  Syntax file written to c:/temp/readZkdData.sps

automateDataPreparation: terminated successfully! 2012-01-20 17:10:39
```


Simple Unidimensional 1PL Model

```
results01 <- automateModels( dataset = dataset , folder = folder )
```


ConQuest Dataset & Label File Creation

labels

```
===> item
1 ER22201
2 ER22202
3 ER22203
4 ER22204
5 ER22205
6 ER30401
...
233 ER33401
234 ER33402
235 ER33403
236 ER33404
237 ER19501
238 ER19502
239 ER20503
240 ER26301
===> dimensions
1 all.i
```

dataset

```
619 3416110111111111110111111......1010011101001010110010.
620 3416110211111111110011111......1111100111101100001000.
621 3416110311111110101111111......1100000001101011101111.
622 3416110411111110101111111......1111111111010100111101.
623 3416110511111010101111111......1110111101000001011110.
624 3416110611111110100111111......0011111111101111100000.
625 3416110711111111000011111......1000000101001101100101.
626 3416110811111110100111111......1111111111011100110000.
627 3416110911111010100111111......0111111111101001011111.
628 3416111011111111100111111......1111101111101010010100.
629 3416111111101111101111111......0110111101001000111000.
630 3416111211111110100011111......0110010101001010101110.
631 3416111311111110100111111000001..........................
632 3416111411111110100111111001011..........................
633 3416111511111111111111111100000..........................
634 3416111611111110101111111110101..........................
635 3416111711111111100111011100100..........................
636 3416111811100110110111111011100..........................
637 3416111911111110000111111001100..........................
638 3416112011101010101011111001010..........................
639 3416112111101010100111111110010..........................
640 3416112211111110100111111000001..........................
641 3516120311111010100111111......1011011111101100000010.
642 3516120411101111100111111......0011111101001000000100.
```


ConQuest Syntax Creation

```
title = Analysis name: all.i__all.p, User: USER212, Computername: PC017,
R version 2.14.1 (2011-12-22), Time: Sun Jan 29 15:18:50 2012;
export logfile >> all.i__all.p.log;
datafile all.i__all.p.dat;
Format pid 1-8 responses 9-248;
codes 1,0;
labels  << all.i__all.p.lab;
score ( 0 1 ) ( 0 1 ) ! items( 1-240 );
set constraints=cases;
set warnings=no,update=yes,n_plausible=5,p_nodes=2000,f_nodes=2000;
export par    >> all.i__all.p.prm;
model item;
estimate ! method=gauss,iter=1000,nodes=15,converge=0.0001,deviancechange=0.0001,
stderr=quick,distribution=normal;
Itanal >> all.i__all.p.itn;
show cases! estimates=latent >> all.i__all.p.pvl;
show cases! estimate=wle >> all.i__all.p.wle;
equivalence wle >> all.i__all.p.equ;
show >> all.i__all.p.shw;
descriptives !estimates=pv >> all.i__all.p_pvl.dsc;
descriptives !estimates=wle >> all.i__all.p_wle.dsc;
quit;
```

ConQuest Run

- ConQuest runs due to automatic creation and execution of batch files

```
C:\Windows\system32\cmd.exe
Variance estimate        ==>  283.00773
Change in the deviance is       0.00012
------------------------------------------

Iteration: 27  ...........................
Deviance =       1482.85105

Variance Estimate:
BF                1839.99838


Mean:
BF                   0.00000

Maximum changes:
Item parameter estimates ==>    0.00046 (Parameter 3)
Mean estimate            ==>    0.00000
Variance estimate        ==>  349.31338
Change in the deviance is       0.00006
------------------------------------------
Deviance change is less than covergence criterion
Iterations will terminate
Calculating fit statistics
```


ConQuest Output Files

- Item parameter estimates
  - .shw, .itn, ...
- Person parameter estimates
  - .wle, .mle, .eap, .pvl, ...

⇒ Many different output files

ConQuest Item Parameter Output

all.i__all.p.itn

```
FF==========================================================================
= Analysis name: all.i__all.p, User: USER"!", ComputernameSun Jan 29 15:20 2012
GENERALISED ITEM ANALYSIS
============================================================================
Item 1
------
item:1 (ER22201)
Cases for this item     247   Discrimination  0.11
Item Threshold(s):     -4.38   Weighted MNSQ   1.04
Item Delta(s):      -4.38
---------------------------------------------------------------------------
 Label     Score      Count   % of tot  Pt Bis      t  (p)    PV1Avg:1 PV1 SD:1
---------------------------------------------------------------------------
   0        0.00        4       1.62    -0.11    -1.71(.089) -0.32      1.35
   1        1.00      243      98.38     0.11     1.71(.089)  0.32      1.00
===========================================================================
```

all.i__all.p.shw

```
FF============================================================================
= Analysis name: all.i__all.p, User: USER212, ComputernameSun Jan 29 15:20 2012
TABLES OF RESPONSE MODEL PARAMETER ESTIMATES
============================================================================
TERM 1: item
------------------------------------------------------------------------------------------
   VARIABLES                                UNWEIGHTED FIT             WEIGHTED FIT
---------------                         -----------------------   -----------------------
     item               ESTIMATE  ERROR^  MNSQ      CI        T   MNSQ      CI         T
------------------------------------------------------------------------------------------
 1  ER22201             -4.378   0.513   2.34 ( 0.82, 1.18) 11.0   1.04 ( 0.07, 1.93)  0.2
 2  ER22202             -3.925   0.423   0.54 ( 0.82, 1.18) -6.1   0.96 ( 0.26, 1.74)  0.0
 3  ER22203             -5.781   1.007   0.58 ( 0.82, 1.18) -5.5   1.03 ( 0.00, 2.94)  0.4
 4  ER22204             -1.283   0.170   1.11 ( 0.82, 1.18)  1.2   1.06 ( 0.81, 1.19)  0.6
 5  ER22205             -4.142   0.461   1.85 ( 0.82, 1.18)  7.6   1.07 ( 0.18, 1.82)  0.3
```


ConQuest Person Parameter Output

all.i__all.p.wle

```
     1  01111101    37.00      48.00    1.06340     0.42056
     2  01111103    38.00      48.00    1.24321     0.43329
     3  01111104    40.00      48.00    1.64186     0.46594
     4  01111105    40.00      48.00    1.64186     0.46594
     5  01111106    45.00      48.00    3.09501     0.65467
     6  01111107    45.00      48.00    3.09501     0.65467
     7  01111108    46.00      48.00    3.56905     0.74690
     8  01111109    36.00      48.00    0.89348     0.40974
     9  01111110    41.00      48.00    1.86715     0.48683
    10  01111111    40.00      48.00    1.64186     0.46594
```

all.i__all.p.pvl

```
  1  01111101
 1          0.52
 2          1.11
 3          1.04
 4          1.06
 5          0.99
 0.95723
 0.38437
  2  01111103
 1          0.38
 2          1.05
 3          1.57
 4          2.08
 5          1.07
 1.10824
 0.39400
  3  01111104
 1          0.97
 2          1.07
 3          2.10
 4          1.12
 5          2.34
 1.44900
 0.43521
```

eat Reporting

Item parameter estimates

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	analysis	dimension	group	item	n.valid	p	a	b	c	d	b.se	infit	infit.ci.lb	infit.ci.ub	infit.t	outfit	outfit.ci.lb	outfit.ci.ub	outfit.t	pbc
2	all.i__all.p	all.i	all.p	ER22601	489	0,52		-0,096			0,228	0,82	0,75	1,25	-1,5	0,13	0,86	1,14	-21,1	0,97
3	all.i__all.p	all.i	all.p	ER22602	489	0,49		0,483			0,234	1,88	0,74	1,26	5,3	1	0,86	1,14	0	0,91
4	all.i__all.p	all.i	all.p	ER22603	489	0,53		-0,358			0,231	1,32	0,74	1,26	2,2	16,53	0,86	1,14	66,4	0,93
5	all.i__all.p	all.i	all.p	ER22604	489	0,52		-0,096			0,228	0,82	0,75	1,25	-1,5	0,14	0,86	1,14	-20,8	0,97
6	all.i__all.p	all.i	all.p	ER22605	489	0,49		0,538			0,236	1,47	0,74	1,26	3,1	0,36	0,86	1,14	-12,5	0,93

Person parameter estimates

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	analysis	dimension	group	person	n.solved	n.total	wle	wle.se	eap	eap.se	pv.1	pv.2	pv.3	pv.4	pv.5
2	all.i__all.p	all.i	all.p	1120011210	0	5	-2,36696	1,64599	-34,9682	25,24358	-66,44	-42,28	-81,59	-17	-30,93
3	all.i__all.p	all.i	all.p	1120019109	5	5	2,55778	1,65001	35,74393	26,45026	9,43	22,41	27,42	18,32	22,97
4	all.i__all.p	all.i	all.p	1140011218	5	5	2,55778	1,65001	35,74393	26,45026	46,4	9,92	24,47	3,59	19,81
5	all.i__all.p	all.i	all.p	1140019107	0	5	-2,36696	1,64599	-34,9682	25,24358	-2,44	-16,11	-22,83	-43,8	-21,21
6	all.i__all.p	all.i	all.p	1140019114	5	5	2,55778	1,65001	35,74393	26,45026	8,46	45,65	72,45	12,19	31,53
7	all.i__all.p	all.i	all.p	1140019127	0	5	-2,36696	1,64599	-34,9682	25,24358	-20,13	-26,22	-9,79	-19,92	-48,85
8	all.i__all.p	all.i	all.p	1211029102	5	5	2,55778	1,65001	35,74393	26,45026	63,45	43,11	36,9	34,25	18,16
9	all.i__all.p	all.i	all.p	1211029106	5	5	2,55778	1,65001	35,74393	26,45026	13,73	52,2	32,86	17,91	31,81
10	all.i__all.p	all.i	all.p	1211029111	5	5	2,55778	1,65001	35,74393	26,45026	2,81	8,9	58,77	47,88	42,22
11	all.i__all.p	all.i	all.p	1220021217	5	5	2,55778	1,65001	35,74393	26,45026	6,07	8,46	60,51	53,7	9,18
12	all.i__all.p	all.i	all.p	1220029115	0	5	-2,36696	1,64599	-34,9682	25,24358	-30,52	-31,62	-31,36	-19,04	-9,63
13	all.i__all.p	all.i	all.p	1221019101	5	5	2,55778	1,65001	35,74393	26,45026	16,54	25,97	13,25	2,08	26,03
14	all.i__all.p	all.i	all.p	1221019105	0	5	-2,36696	1,64599	-34,9682	25,24358	-34,27	-6,23	-56,56	-12,46	-25,5
15	all.i__all.p	all.i	all.p	1221019112	5	5	2,55778	1,65001	35,74393	26,45026	15,07	14,95	10,52	13,25	39,2

eat Log

- all objects (dataset, item.grouping, ...) will be archived into an .RData file
- an INFO file will be created

```
MODEL INFORMATION

Model Name:             all.i__all.p
Dimensions:             1 (unidim)
Dimension Names:        all.i
Groups:                 1 (singlegroup)
Group Names:            all.p
Measurement Model:      1pl
Software:               conquest
DIF:                    none
Regression:             none
Anchor:                 none
Missing Rule:           mvi = 0, mnr = 0, mci = NA, mbd = NA, mir = 0, mbi = 0
Deskr. Gruppenvar.:     none
Deskriptive Gruppen:    none

Generated:              2012-01-29 15:20:31
User:                   USER212
Userdomain:             user
Computername:           PC017
```


Multidimensional vs. Unidimensional Analysis

```
results02 <- automateModels( dataset = dataset , id = "id" , folder = folder ,
      item.grouping = item.grouping ,
      select.item.group = c ( "ER" , "EL" ) )

results03 <- automateModels( dataset = dataset , id = "id" , folder = folder ,
      item.grouping = item.grouping ,
      select.item.group = c ( "ER" , "EL" ) , cross="all")
```

```
> item.grouping
      item ER EL EW
1  ER22201  1  0  0
2  ER22202  1  0  0
3  ER22203  1  0  0
4  ER22204  1  0  0
5  ER22205  1  0  0
6  EL30101  0  1  0
7  EL30102  0  1  0
8  EL23401  0  1  0
9  EL23402  0  1  0
10 EL23403  0  1  0
11 EW00101  0  0  1
12 EW00102  0  0  1
13 EW02301  0  0  1
14 EW02302  0  0  1
15 EW02303  0  0  1
```


Person groups & weights

```
dataset <- cbind ( dataset , "weight1" = as.character(sample(c(0.8, 1, 1.2),
      nrow(dataset), replace=TRUE)), "weight2" = as.character(sample(c(1),
      nrow(dataset), replace=TRUE)), stringsAsFactors = FALSE )

results04 <- automateModels( dataset = dataset, folder = folder
      context.vars = c ( "weight1" , "weight2" ) ,
      item.grouping = item.grouping ,
      select.item.group = "ER" ,
      person.grouping = person.grouping ,
      select.person.group = list ( "gr.9" , "gr.10" ) ,
      weight = list ( "weight1" , "weight2" ) )
```

automateModels – Overview

```
automateModels(dataset, id = NULL, context.vars = NULL, items = NULL,
      item.grouping = NULL, select.item.group = NULL,
      person.grouping.vars = NULL, person.grouping.vars.include.all = FALSE,
      person.grouping = NULL, select.person.group = NULL,
      additional.item.props = NULL, folder, overwrite.folder = TRUE,
      analyse.name.prefix = NULL, analyse.name = NULL,
      analyse.name.elements = NULL, data.name = NULL, m.model = NULL,
      software = NULL, dif = NULL, weight = NULL, anchor = NULL,
      regression = NULL, adjust.for.regression = FALSE, q3 = FALSE,
      missing.rule = NULL, cross = NULL, subfolder.order = NULL,
      subfolder.mode = NULL, additionalSubFolder = NULL, run.mode = NULL,
      n.batches = NULL, run.timeout = 1440, run.status.refresh = 0.2,
      email = NULL, smtpServer = NULL, write.txt.dataset = FALSE,
      delete.folder.countdown = 5, conquestParameters = NULL )
```


Thank you

- Thank you for your attention!

  http://r-forge.r-project.org/eat

  eat-commits@lists.r-forge.r-project.org

- Special thanks to

  Alexander Robitzsch (Measurement Statistician, bifie)
  Martin Mechtel (IT Director, IQB)