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

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Overview

1. eat - History
   - The Institute for Educational Quality Improvement
   - ACER ConQuest
   - The Idea
2. eat - Concept
   - Overview
   - Data
3. eat - Examples
   - Data Preparation
   - Unidimensional 1PL model with automateModels
   - Grouping options in automateModels
   - automateModels
4. Discussion
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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

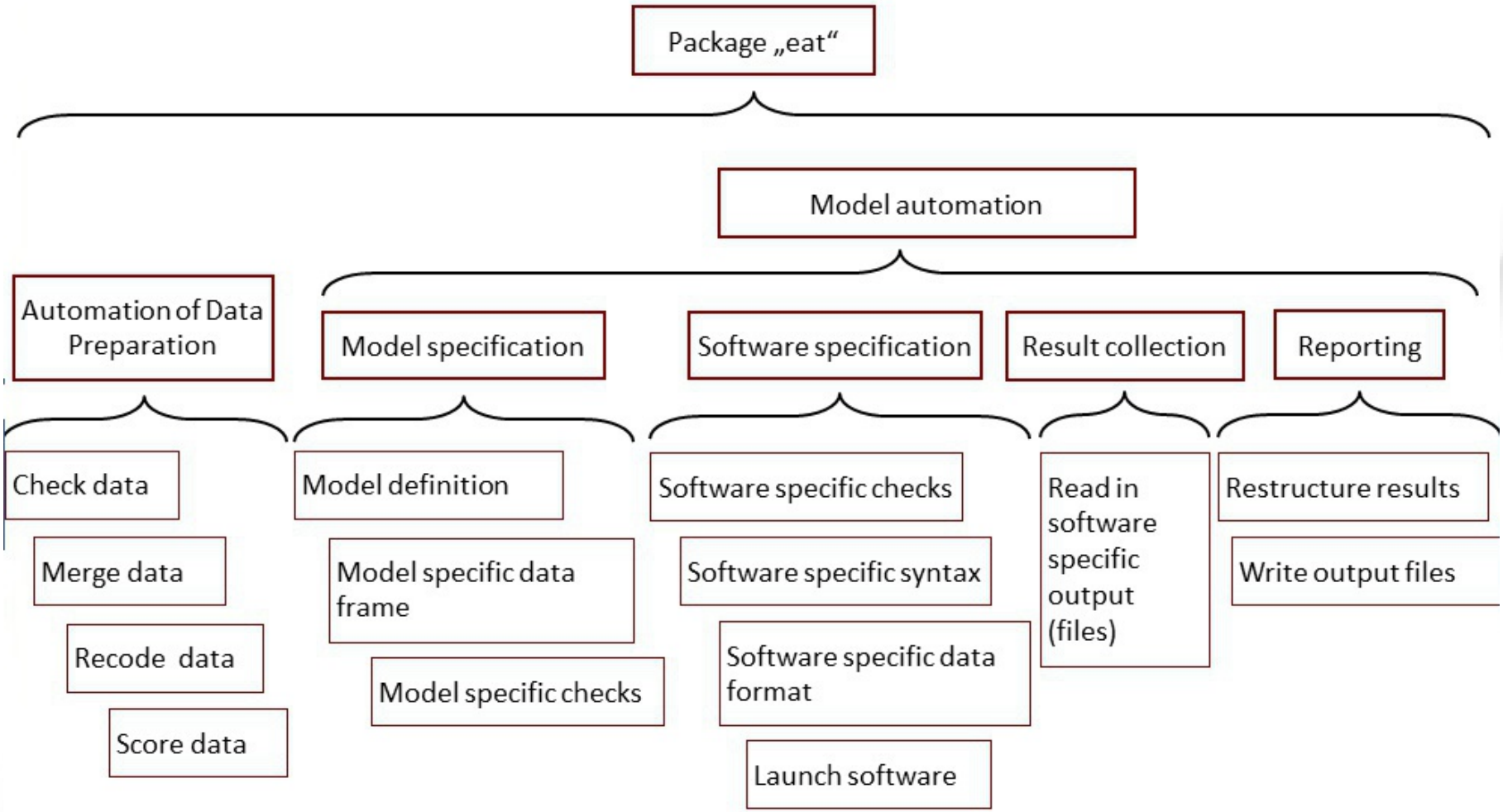
- Commercial Software developed by ACER (Wu, Adams & Wilson, 1997)
- Major scaling tool of the Organisation for Economic Co-operation and Development's Programme for International Student Assessment (PISA)
- Fits a large number of different item response models
  - Rasch, partial credit, rating scale, 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

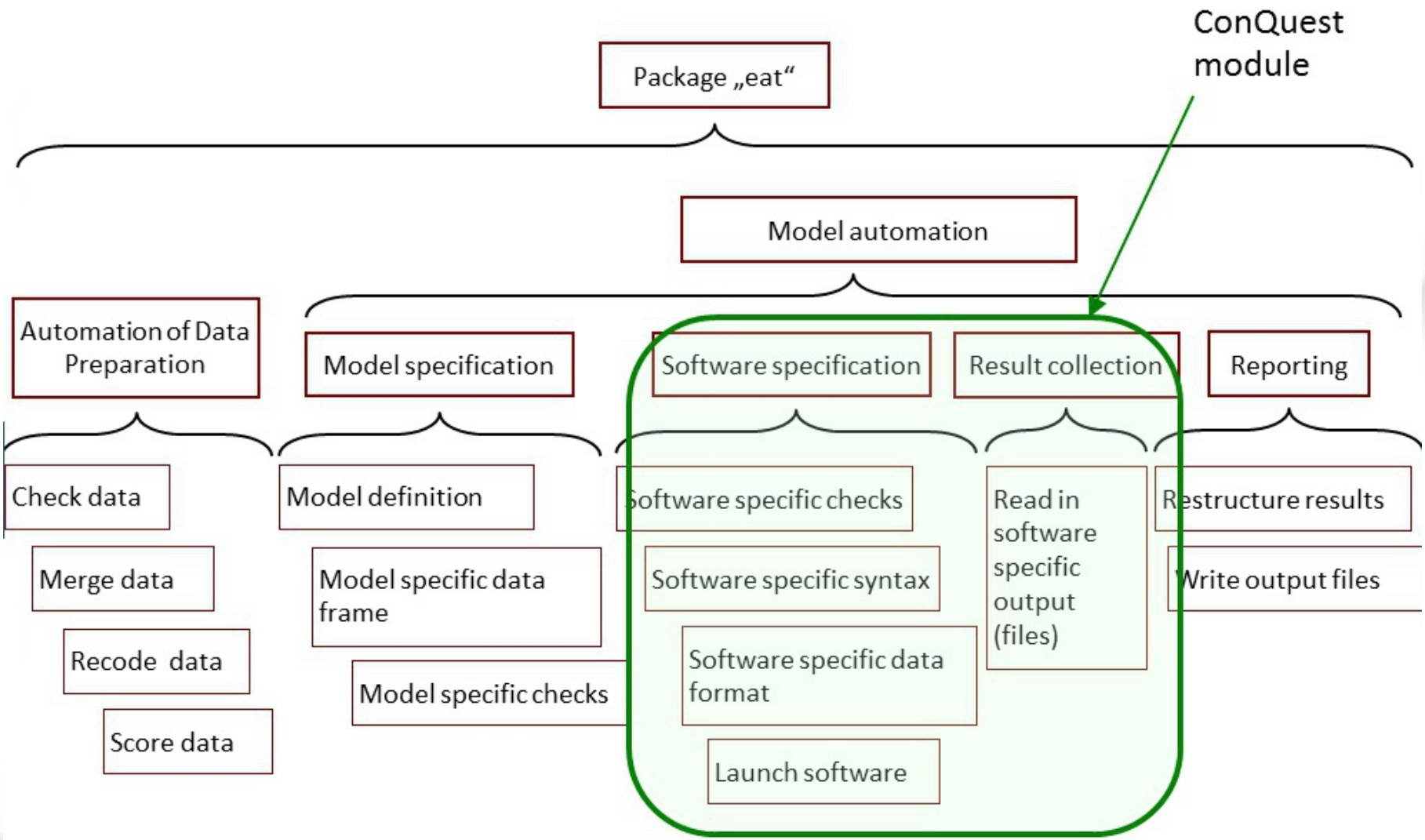
- automate data preparation
  1. read in & check SPSS-files
  2. merge data frames (booklets)
  3. recode & dichotomize data
- automate IRT calibration
  1. write ConQuest syntax, generate appropriate data input
  2. execute ConQuest
  3. read in ConQuest output
- facilitate reporting
  1. write out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

$\Rightarrow$ "eat" ("Educational Assessment Tools")

Implemented Modules



Wrapping ConQuest



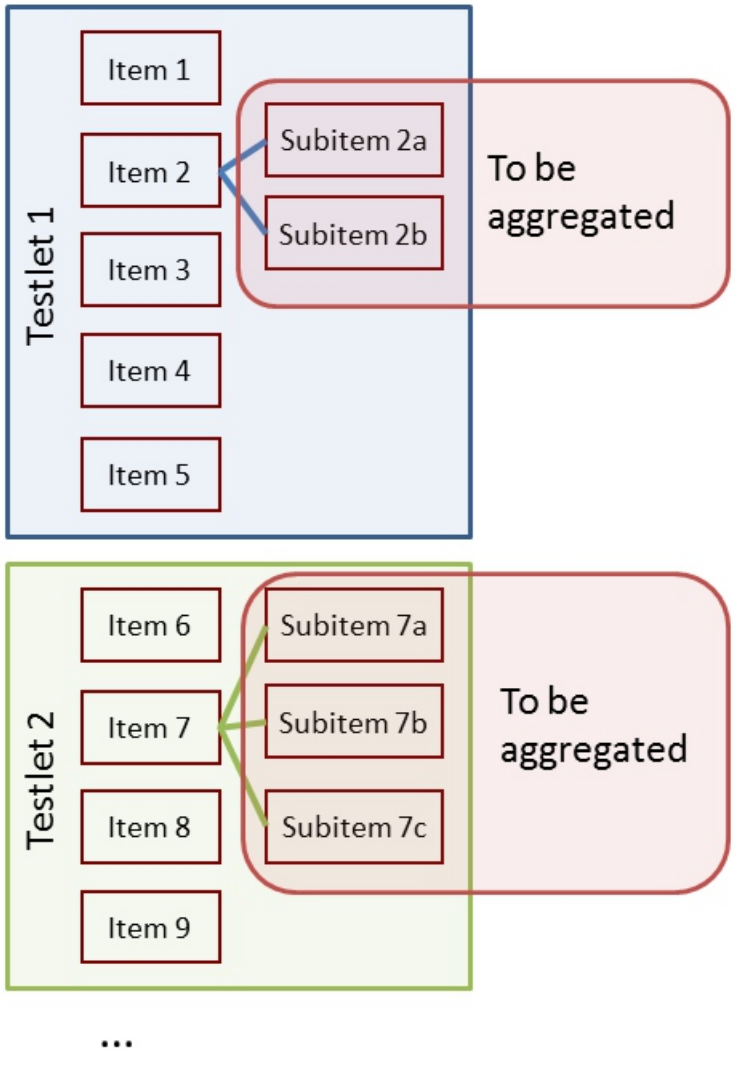
Typical Items

	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



1. Recode all Items & Subitems
2. Aggregate Subitems
3. Recode aggregated Subitems

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

```
1  ------------------------------------------------------------------------------
2  | 2012-01-20 17:10:28 | USER212 | PC017 | R version 2.14.0 (2011-10-31) /i386 |
3  ------------------------------------------------------------------------------
4  automateDataPreparation: Starting automateDataPreparation 2012-01-20 17:10:28
5
6  automateDataPreparation: Load .sav Files
7
8  automateDataPreparation: Check data...
9  .checkData.checkID: Only valid codes in ID variable.
10 .checkData.checkID: No duplicated entries in ID variable.
11 .checkData.checkVars: No duplicated variable names.
12 .checkData.checkCodes: Found no invalid codes.
13 .checkData.checkMissings: Case(s)23 contain(s) only missing values.
14
15 automateDataPreparation: Start merging
16 mergeData_0.4.0: Start merging of dataset 1.
17 mergeData_0.4.0: Start merging of dataset 2.
18 mergeData_0.4.0: Start merging of dataset 3.
19
20 automateDataPreparation: Start recoding
21 recodeData_1.0.1: ER52501 has been recoded.
22 recodeData_1.0.1: ER52502a has been recoded.
23 recodeData_1.0.1: ER52502b has been recoded.
24 recodeData_1.0.1: ER52503 has been recoded.
25 recodeData_1.0.1: ER52504 has been recoded.
26 recodeData_1.0.1: ER52505 has been recoded.
27
28 automateDataPreparation: Start aggregating
29 aggregateData_1.2.0: Aggregate unit ER52502.
30
31 automateDataPreparation: Start scoring
32 recodeData_1.0.1: ER52502 has been recoded.
33
34 automateDataPreparation: Writing dataset in last transformation status to disk
35 writeSpss_0.2.0:  Data values written to c:/temp/zkddata.txt
36 writeSpss_0.2.0:  Syntax file written to c:/temp/readZkdData.sps
37
38 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

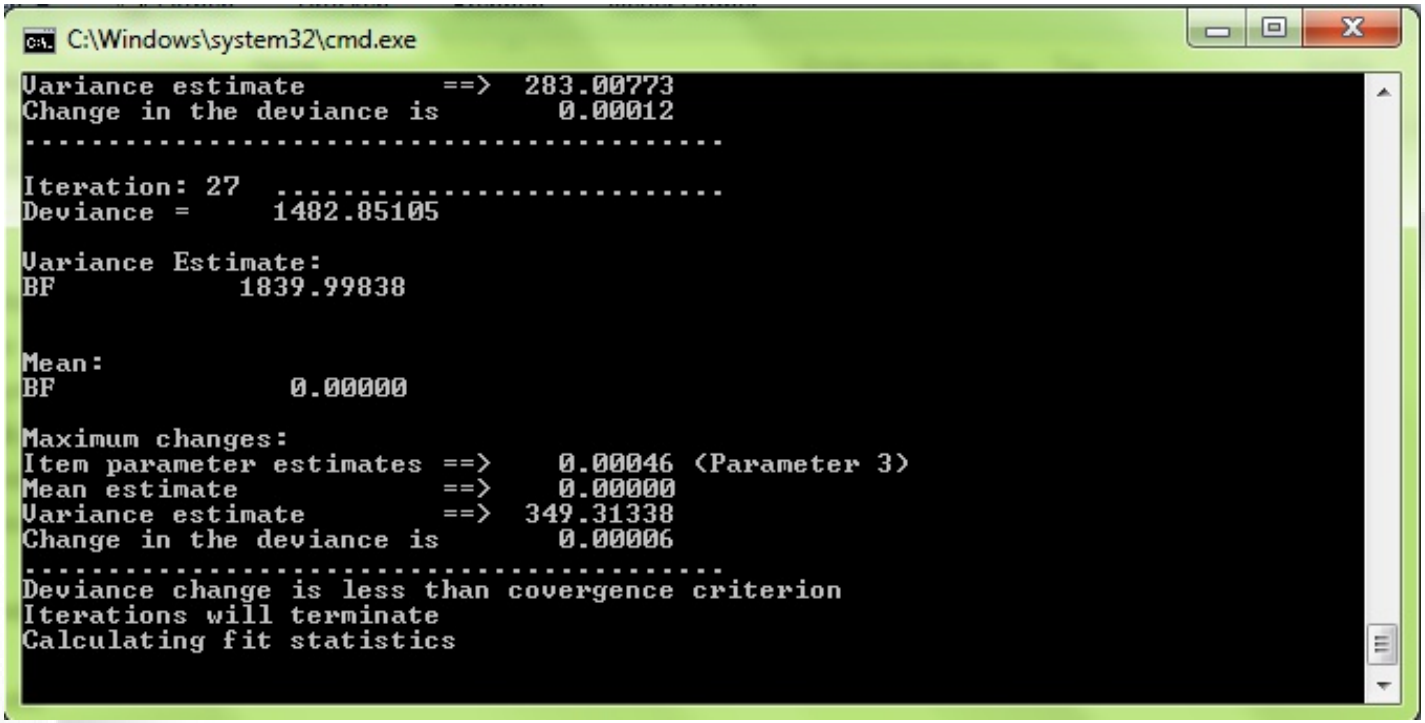
```
341611011111111111110111111.....10100111010010101100100.
341611021111111111100111111.....11111001111011000010000.
341611031111111101010111111.....11000000011010111011110.
341611041111111101010111111.....11111111111010100111101.
341611051111101010111111.....11101111010000010111101.
341611061111111101010011111.....00111111111011111000000.
341611071111111100000111111.....10000001010011011001011.
341611081111111101010011111.....11111111111011100110000.
341611091111101010010111111.....01111111111010010111111.
341611101111111111110011111.....11111011111010100101001.
341611111111101111101111111.....01101111010010001110000.
341611121111111101000111111.....01100101010010101011101.
341611131111111101001111000001.....
341611141111111101001111001011.....
341611151111111111111111100000.....
341611161111111101011111110101.....
341611171111111111001101100100.....
341611181110011011011111011100.....
341611191111111000011111001100.....
341611201110101010101111001010.....
341611211110101010011111110010.....
341611221111111101001111000001.....
351612031111101010011111.....10110111111011000000101.
351612041110111110011111.....00111111010010000001000.
```

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



ConQuest Output Files

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

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

all.i__all.p.pvl

```
 1   1  01111101
 2  1          0.52
 3  2          1.11
 4  3          1.04
 5  4          1.06
 6  5          0.99
 7  0.95723
 8  0.38437
 9   2  01111103
10  1          0.38
11  2          1.05
12  3          1.57
13  4          2.08
14  5          1.07
15  1.10824
16  0.39400
17   3  01111104
18  1          0.97
19  2          1.07
20  3          2.10
21  4          1.12
22  5          2.34
23  1.44900
24  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)
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