# Data analysis of examination papers

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# Agenda & introductory comments

Evaluation of performance analysis - overview of some aspects

Brief discussion of methods

(not easily transferable) Results

- rather a pilot study, to show what kinds of questions may by raised and solved

- technical characteristics: no automated data collection as could be e.g. in e-learning systems with possibility to use built-in analytical reports with predefined structure - > custom design

# Exams / Types of analyses

- univariate analysis - distribution of total score (response)
- examine structure (+ items to response relation)
- relate performance to other characteristics (socio-demographic, attendance,...)

# Analytical questions addressed

1) What are the most predictive parts of the test with respect to overall score result in the test?

2) Considering performance of students expressed in scores obtained for solution of particular items, are there any significant dependencies between particular problem areas included in the test?

3) Are there any groups of students who are similar with respect to performance in test?

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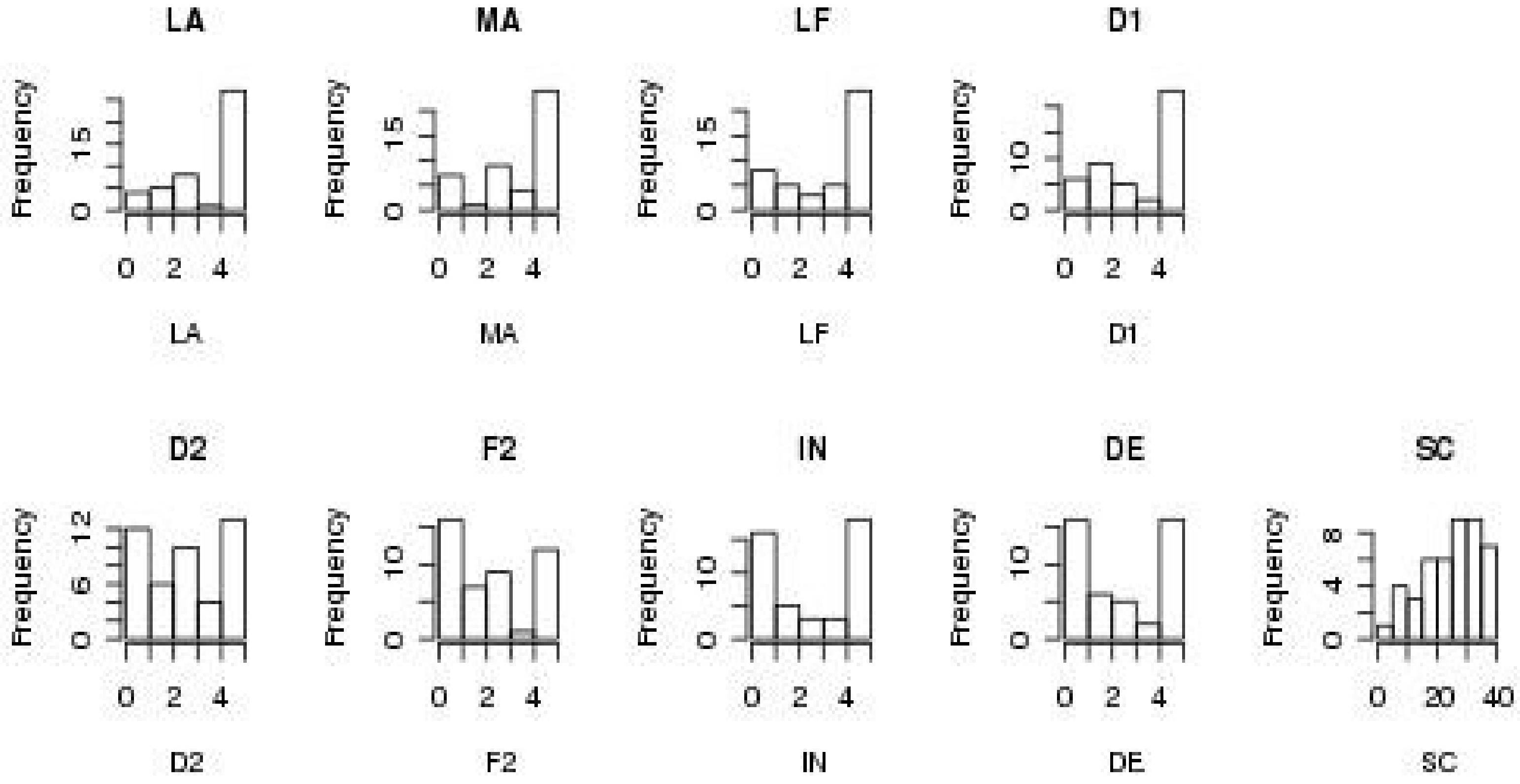
Other analyses may include: search for common factors influencing performance in tests, examination of reliability of tests and analysis of sources of variability (incl. investigation of effect of examiners)

# Data description

- *N=45* examination papers in a basic „all-in-one“ course of mathematics, tests have the same structure – 8 tasks each
- *Expert classification of tasks (-> analysis of metadata)*
- basic linear algebra calculations ( denoted LA), matrix algebra task (MA), limit calculation (LF), item focused on rather straightforward derivatives application (D1), item including a more difficult application of derivatives (D2), integral calculation (IN), optimization of a function of two variables (F2) and solving a differential equation (DE)
- overall score (SC) as sum of all 8 evaluations for particular test items

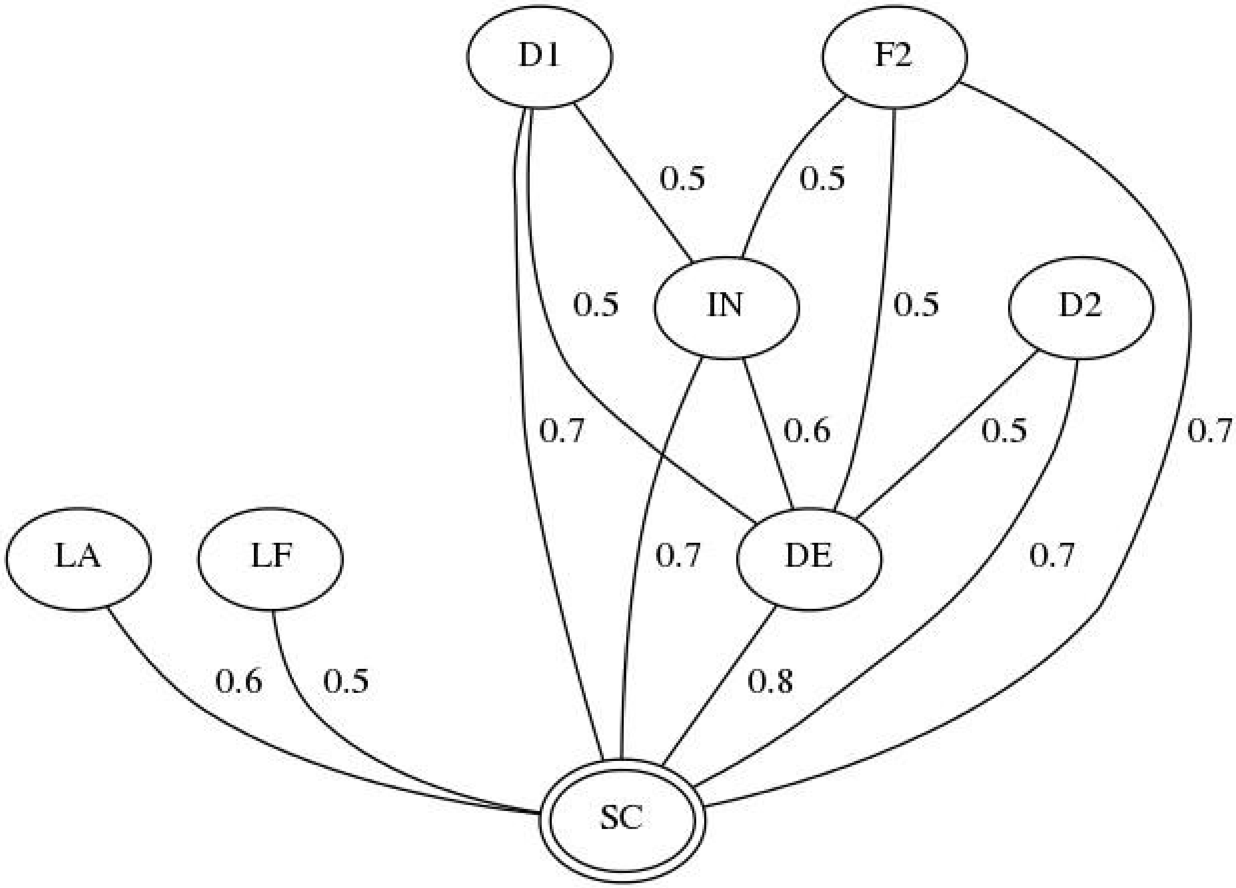
$$SC = LA + MA + LF + D1 + D2 + IN + F2 + DE$$

# Basic exploratory analysis - histograms



# Results / dependency graph

Edges evaluated with Spearman correlation



# Results / graphical model

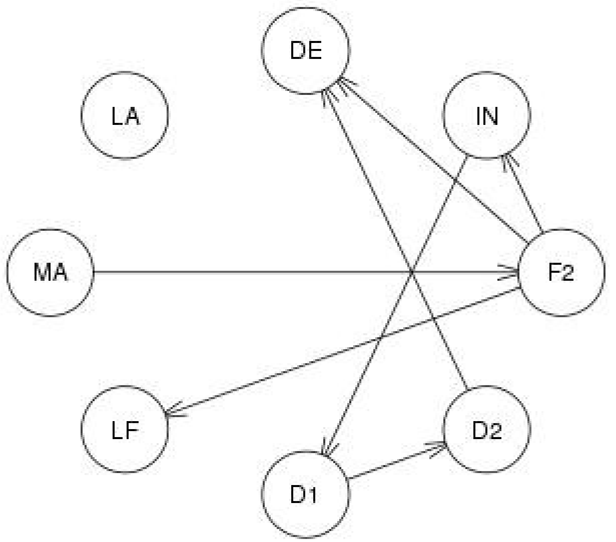
Directed acyclic graph (node represents random variable) and set of density functions – for each node *U in form P(U|parents(U))*

*Factorization of joint probability function* (chain rule):

P(LA,MA,LF,D1,D2,IN,DE, F2 ) =

P(LA)P(MA)P(F2|MA)P(LF|F2)P(IN|F2)P(D1|IN)P(D2|D1)P(DE|D2,F2)

Possibility to capture conditional independence relations



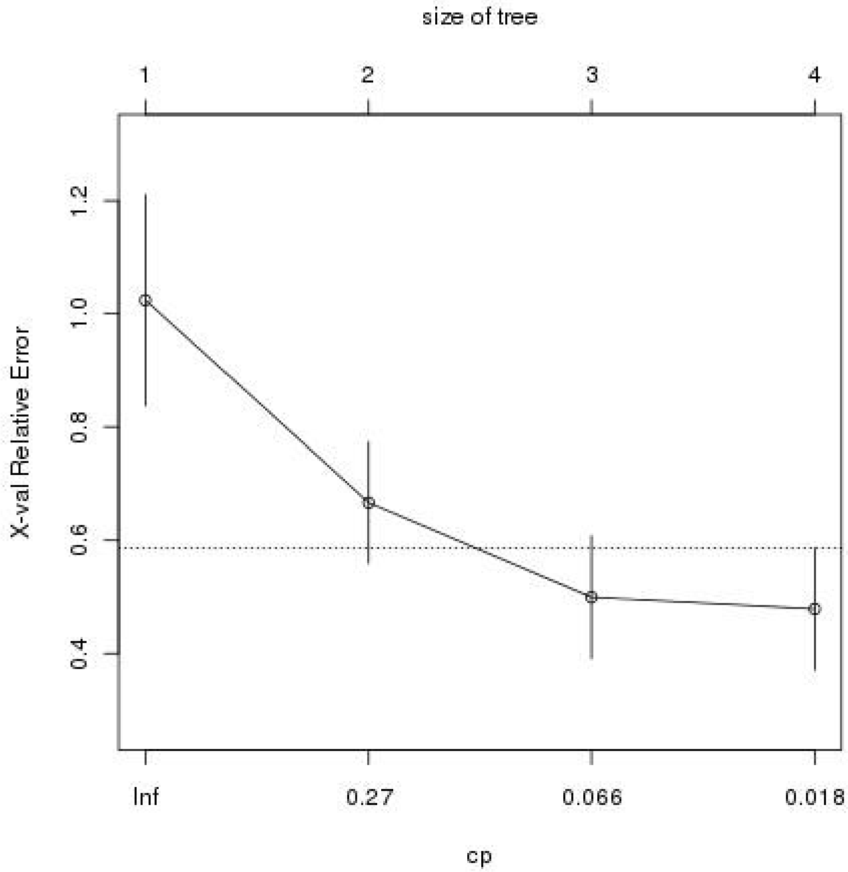
# Method: Regression tree

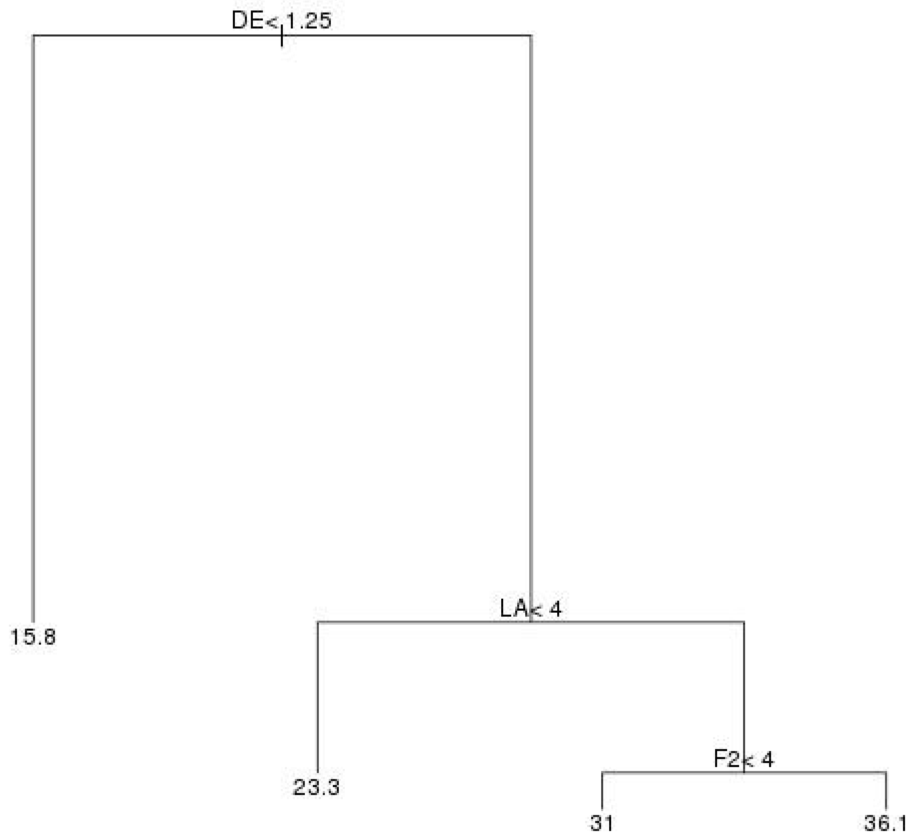
- Predicting value of (continuous) variable SC
- Tree construction – by recursive partitioning of input data set according to the variable with the highest discrimination power

Advantages:

- Possibility to capture interactions and dependencies valid just for particular subsets of data
- Weak assumptions; possibility to deal with missing values
- Easy interpretation of model
- Identification of important variables

# Results / SC prediction - regression tree

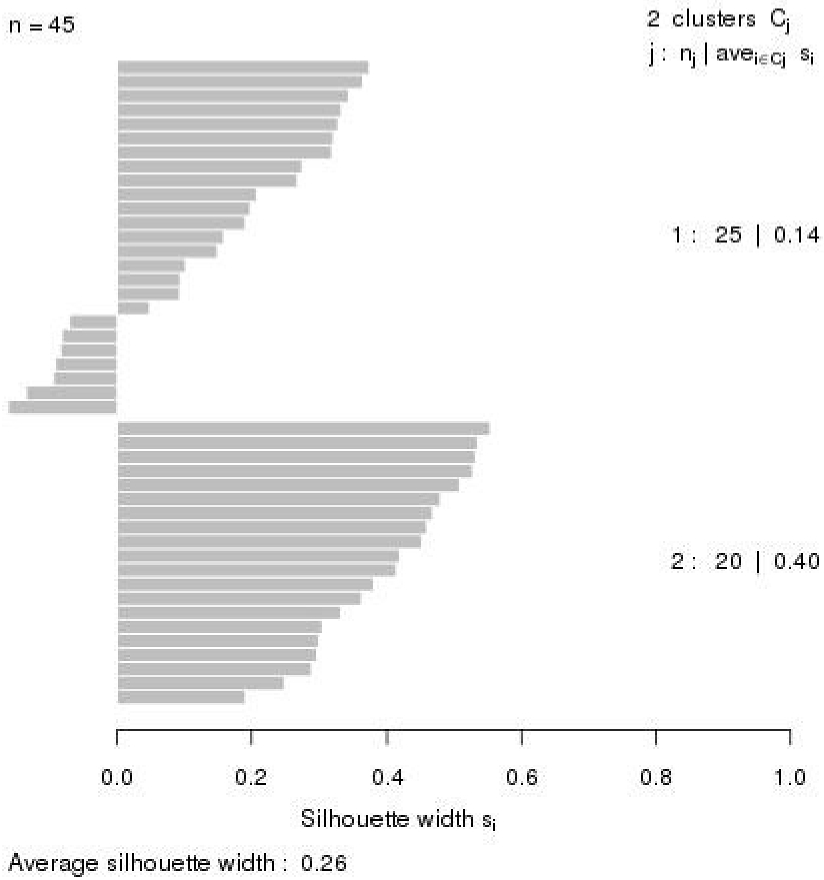


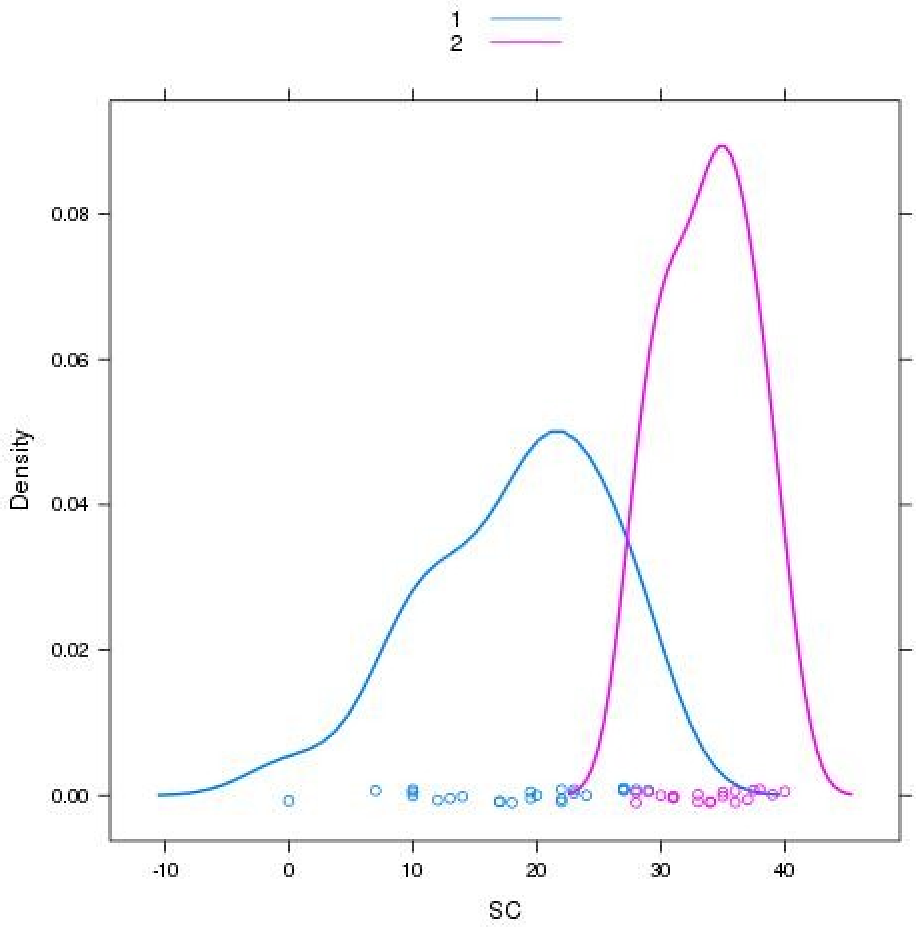




DE, LA and F2 variables chosen as predictors

# Results / cluster analysis

- 2 groups found (avg. silhouette width 0.26; PAM method)
- „Well-performers“ being the more clearly defined group



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