

# A Data Mining Approach for Detecting Collusion in Unproctored Online Exams

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## Setting

- Data from the *Descriptive Statistics* course at U Duisburg-Essen, Germany
- Exams consist of arithmetical problems, programming tasks in R, and a short essay task
- Exams are conducted digitally with the e-assessment system JACK
  - Each student receives different randomized numerical values across all tasks
  - Event logs capture students' activities, time stamps, and points during the exams for every subtask

Table 1: Overview of the test and comparison group

|              | Comparison | Test        |
|--------------|------------|-------------|
| Year         | 18/19      | 20/21       |
| N            | 109        | 151         |
| Style        | proctored  | unproctored |
| Total points | 60         | 60          |
| Sub tasks    | 19         | 17          |
| Duration     | 70         | 70          |

- The test group (2020/21) took the unproctored exam at home
  - The comparison group (2018/19) took a proctored exam at the university
- Data cleaning is conducted, removing student with
  - Minimal participation
  - Minimal achievement
  - Internet problems

### Aim of the Paper

Detecting potential collusion with a hierarchical clustering algorithm on event logs and strengthen the analysis with a proctored comparison group

## Methodology

- The study utilizes an agglomerative (bottom-up) hierarchical clustering algorithm characterized by the following equation:

$$D(s_i, s_{i'}, v_i, v_{i'}) = \frac{1}{h} \sum_{j=1}^h (w_j^P \cdot d_j^P(s_{ij}, s_{i'j}) + w_j^L \cdot d_j^L(v_{ij}, v_{i'j}))$$

- $D(s_i, s_{i'}, v_i, v_{i'})$  global pairwise dissimilarity
- $d_j^P(s_{ij}, s_{i'j})$  points dissimilarity for each task  $j$
- $d_j^L(v_{ij}, v_{i'j})$  students event patterns dissimilarity for each task  $j$
- $\sum_{j=1}^h w_j^P + w_j^L = 1$  weight of each attribute  $h$

- We reduce the weights for
  - R-tasks, as these tasks have more noise
  - Essay questions, as comparisons on these kinds of tasks are limited
  - Points achieved

- Dissimilarities in points achieved for each task  $j$

$$d_j^P(s_{ij}, s_{i'j}) = |s_{ij} - s_{i'j}|$$

- $s_{ij}$  denotes the points achieved by student  $i$  in the  $j$ -th subtask
- Manhattan metric

- Dissimilarities in the students event patterns (time of submission) for each task  $j$

$$d_j^L(v_{ij}, v_{i'j}) = \sum_{m=1}^{K=70} |v_{ijm} - v_{i'jm}|$$

- $d_j^L(v_{ij}, v_{i'j})$  students event patterns dissimilarity for each task  $j$
- Examination is divided into  $m = 1, \dots, 70$  time intervals
- $v_{ijm}$  denotes the number of answers of student  $i$  for task  $j$  in the  $m$ -th interval

## Empirical Results

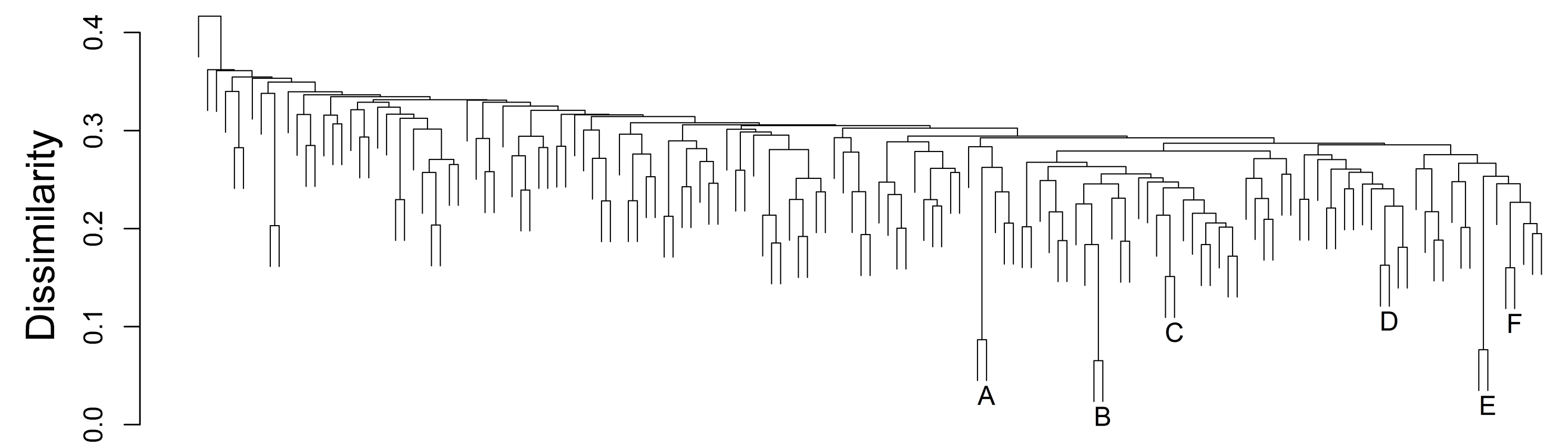


Figure 1: Dendrogram produced by average linkage clustering of the unproctored test group (2020/21). **A-F** mark the clusters with the lowest dissimilarity.

- Figure 1 shows the dendrogram of the **test** group
  - Overall a lower level of dissimilarity compared to the comparison group
  - Six clusters (**A-F**) standing out noticeably from the rest of the cohort, suggesting potential collusion
  - The distance between notable clusters and the median distance is greater than in the comparison group

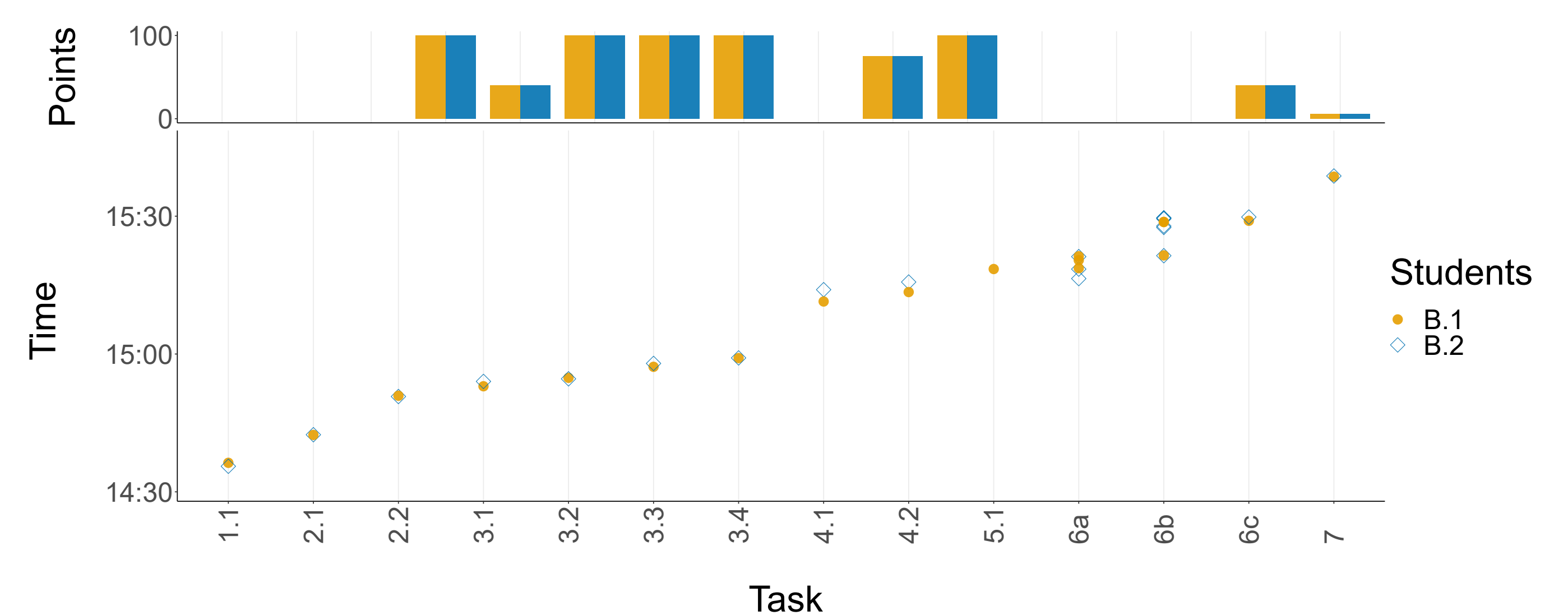


Figure 2: Event logs and achieved points of the cluster **B** from the test group (2020/21). Above the scatter plot, a bar chart is added to compare the points per subtask.

- Figure 2 illustrates the individual comparison of achieved points and event logs of the student cluster with the highest similarity
  - Similar time path
  - Achieved same points for each task

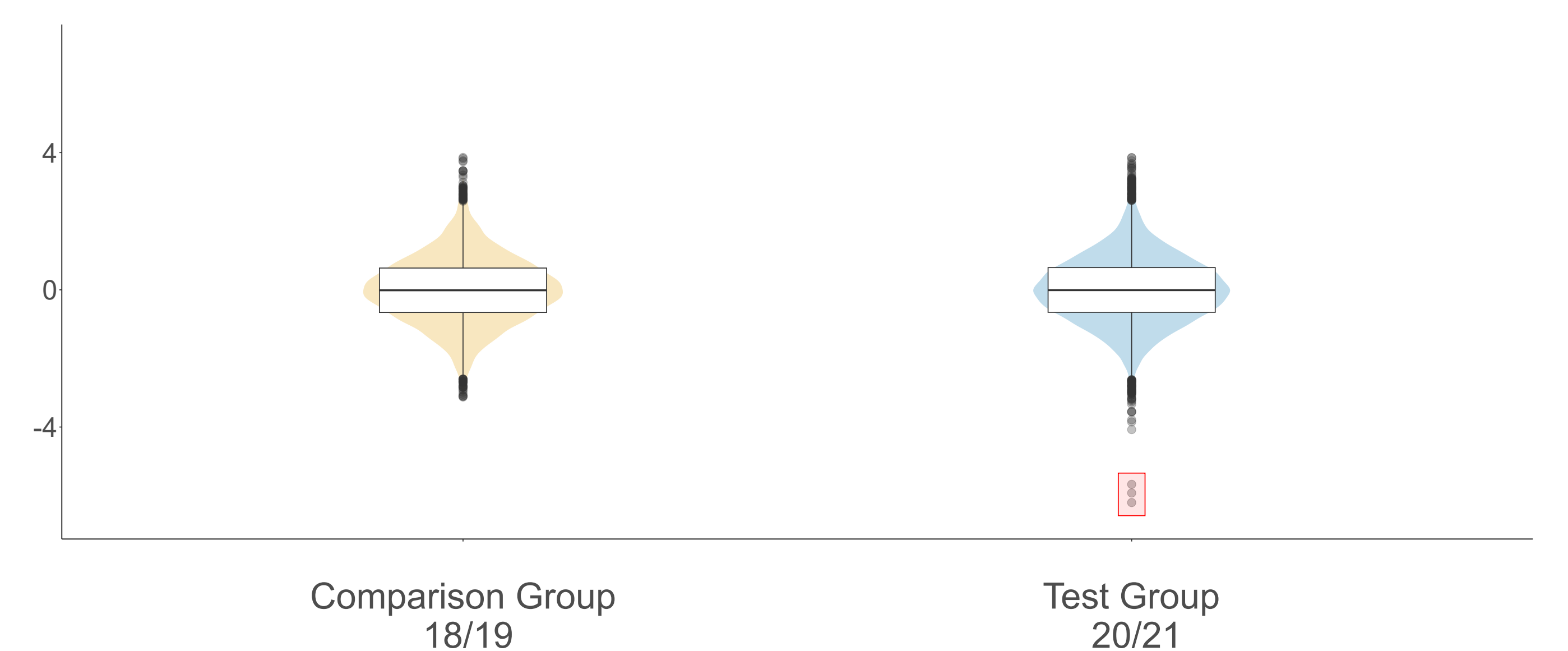


Figure 3: Comparison of the normalized distance measures.

- Figure 3 compares the normalized distributions of the dissimilarity measures between the comparison and test groups

## Discussion

- Six notable clusters (especially **A**, **B**, and **E**), each consisting of two students
- Collusion in larger groups is not found
- Findings do not depend on linkage methods and parameter specifications
- The approach provides a basis for the examination of clusters based on comparison with a reference group