Detecting Changes in Student Behavior from Clickstream Data

Jihyun Park, Kameryn Denaro, Fernando Rodriguez, Padhraic Smyth, Mark Warschauer

UNIVERSITY OF CALIFORNIA, IRVINE

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Overview

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Clickstream Data

- **Learning Management System (LMS)**
  - New way of interacting with the course material
  - e.g. **Canvas**, Blackboard, etc.

- **Clickstream Data from Canvas**

RandomID	URL	Categories	Action	Created_at	Remote_ip
103445	https://canvas.eee.uci.edu/courses/00	homepage	show	2016-03-22T19:48:13Z	128.195.96.251
103445	https://canvas.eee.uci.edu/courses/00 **/discussion_topics**	discussion_ topics	index	2016-03-22T19:47:47Z	128.195.96.251
103445	https://canvas.eee.uci.edu/courses/00 **/assignments**	assignments	show	2016-03-22T19:47:44Z	128.195.96.251
103445	https://canvas.eee.uci.edu/courses/00 **/grades**	grades	grade_ summary	2016-03-22T19:47:33Z	128.195.96.251
103445	https://canvas.eee.uci.edu/courses/00 **/files**/526513?module_item_id=4528	files	show	2016-03-18T05:38:48Z	128.195.96.251
103445	https://canvas.eee.uci.edu/courses/00 **/modules**	modules	index	2016-03-18T05:38:45Z	128.195.96.251

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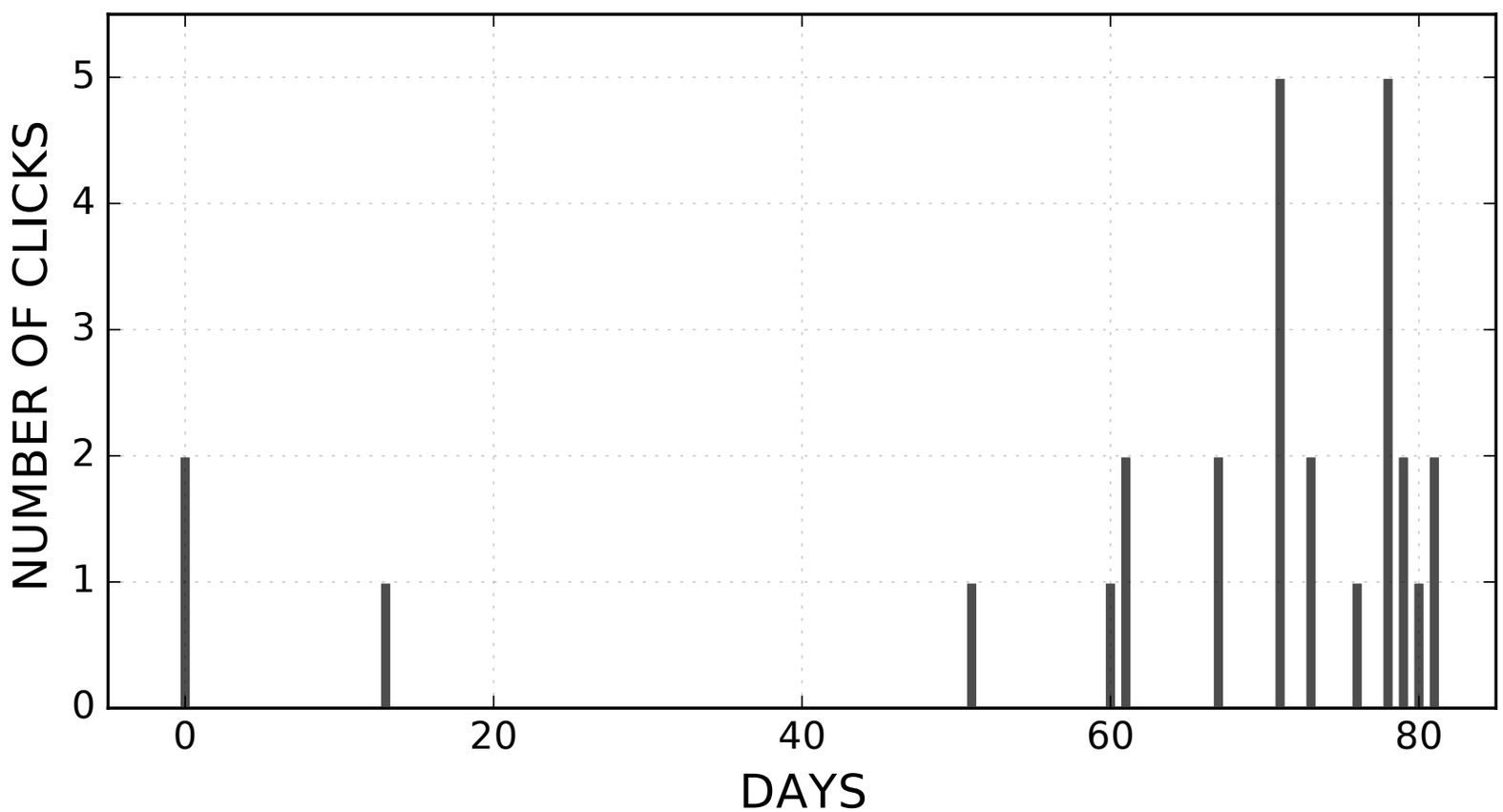
Clickstream Data

- **Number of click events per day, for each student**
  - For example,



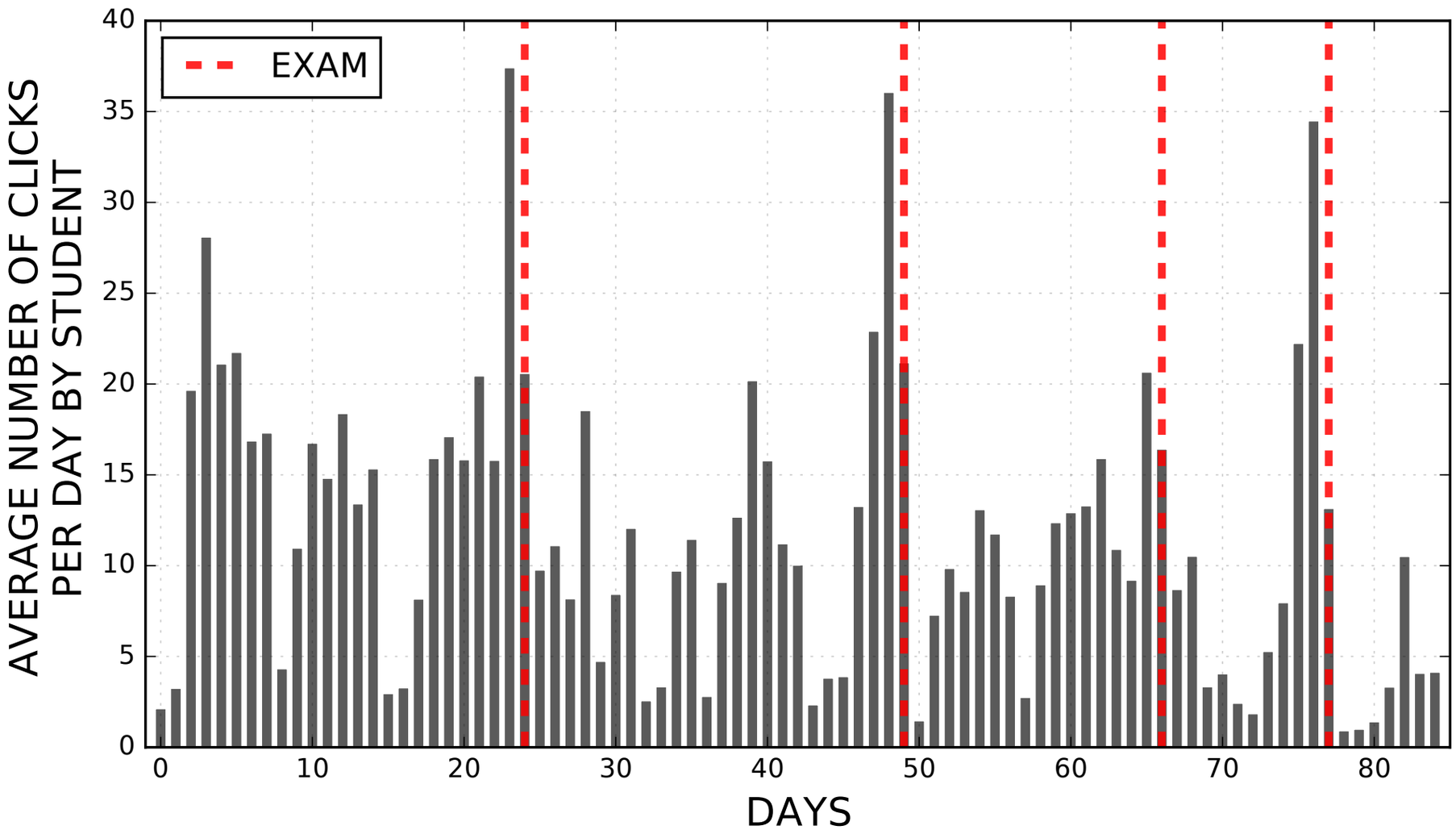
Clickstream Data

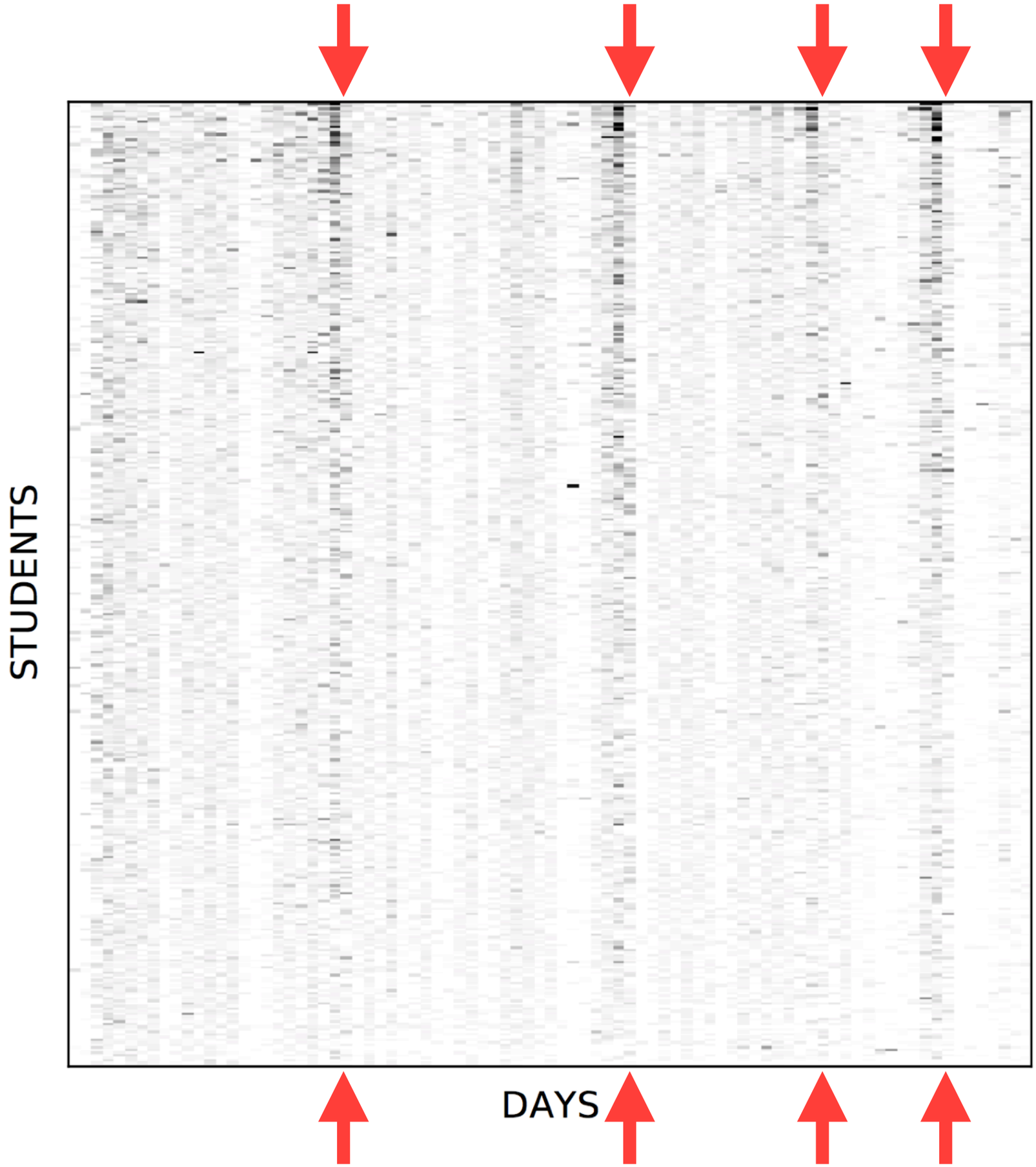
- **Course data from UC Irvine**
  - 10-week face-to-face course
  - 85 days
  - 377 students

- **Simulated data**
  - 85 days
  - 400 students
    - 200 students with rate change at some point
    - 200 students with a single rate

Aggregate Behavior

- **Clickstream data** from the learning management system (LMS)





377 Rows
85 Cols

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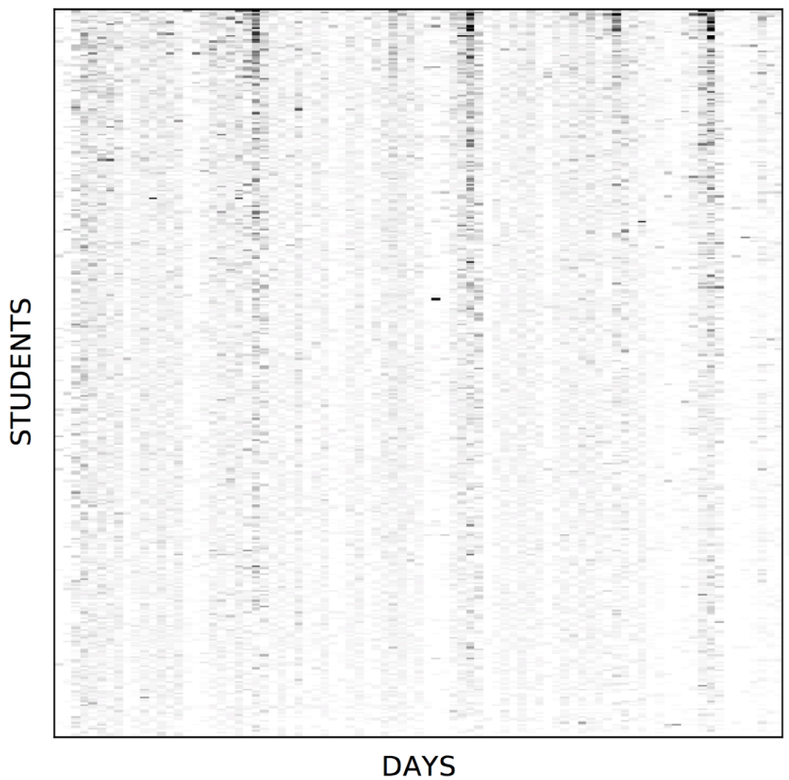
Motivation



- **Develop statistical methods**
  - More information at the level of individual students
  - Student course engagement
- **Change detection technique**
  - Detect meaningful change
  - e.g.) Student activity change vs. course outcome

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- Modeling Student Behavior
- Detecting Changepoint

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Poisson Regression Model

- **Poisson distribution**
  - Distribution for 'counts'
  - One parameter 'mean' : λ

- **Model the mean parameter $\lambda_{i,t}$**
  - for student i
  - on day t

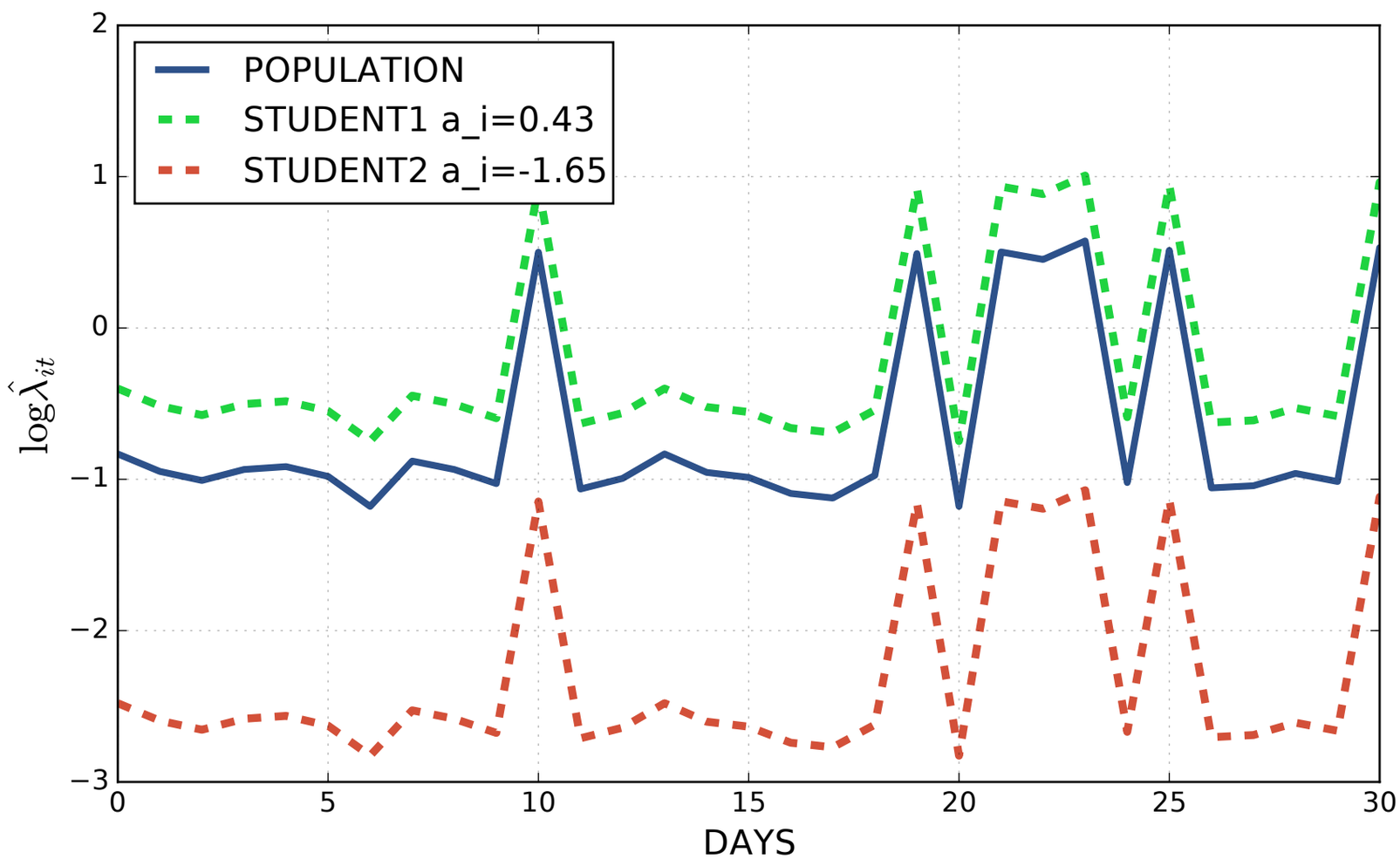
(In our paper we also described Bernoulli model for binary data)

Modeling Student Click Behavior

Function of
Population Mean Rate
at time t

Individual
Random Effect
for student i

$$\log \lambda_{it} = \mu_t + \alpha_i$$

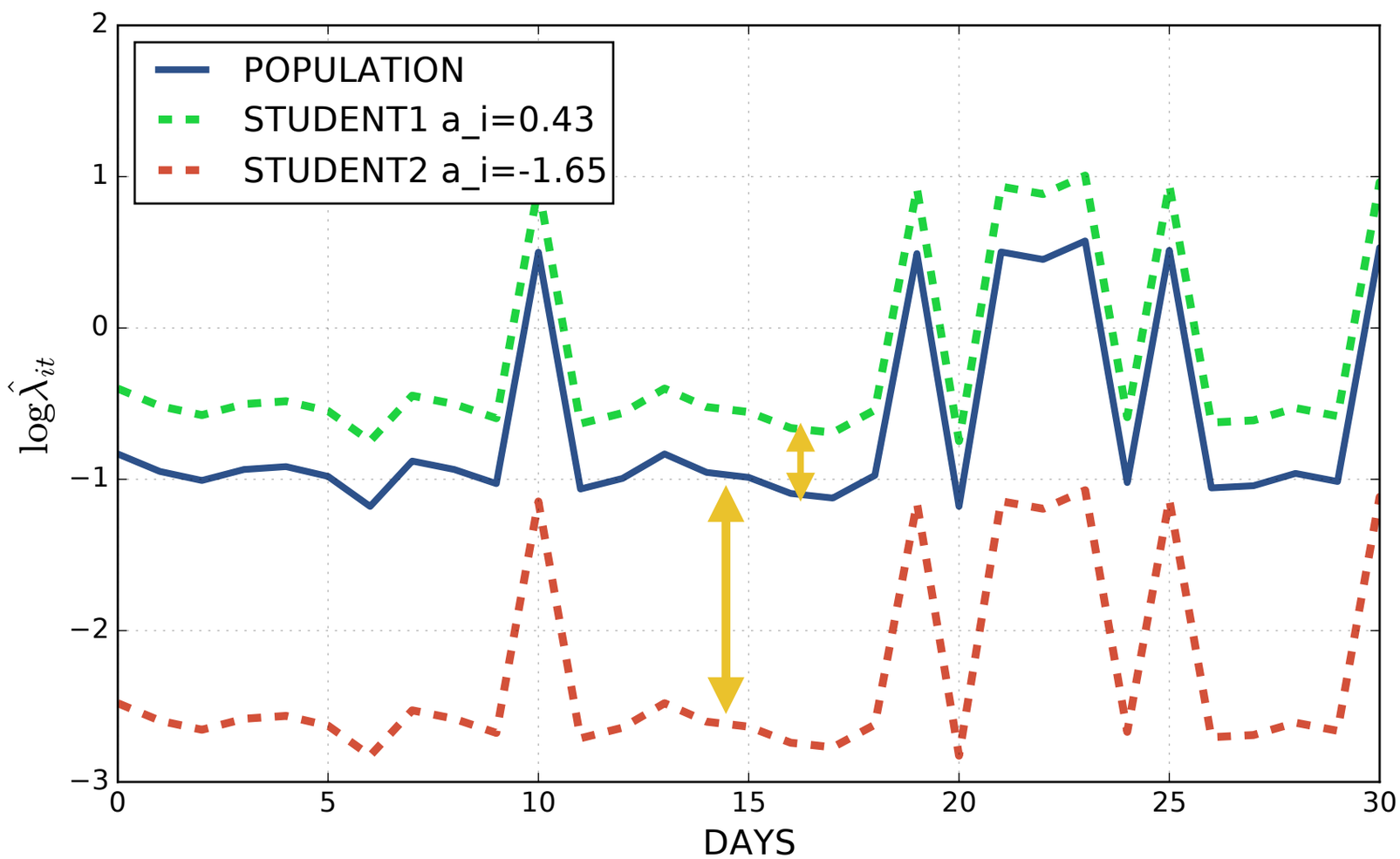


i : student
t : days

Modeling Student Click Behavior

Pattern Offset/Shift

$$\log \lambda_{it} = \mu_t + \alpha_i$$



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Changepoint Detection

For each student,

- **Step 1**

  Find a model with changepoint → **M2 Model with Changepoint**

- **Step 2**

  Select the better model by comparing BIC scores

Compare (**M1 Model without Changepoint** , **M2 Model with Changepoint**)

Step1: Find the Changepoint

- Fit **two regression models**
  one **before** the changepoint and one **after** the changepoint

$$\log \lambda_{it} = \mu_t + \alpha_{i1}\mathbf{I}(t < \tau_i) + \alpha_{i2}\mathbf{I}(t > \tau_i)$$

i : student
t : days

Step1: Find the Changepoint

- Fit **two regression models**
  one **before** the changepoint and one **after** the changepoint

$$\log \lambda_{it} = \mu_t + \alpha_{i1}\mathbf{I}(t < \tau_i) + \alpha_{i2}\mathbf{I}(t > \tau_i)$$

i : student
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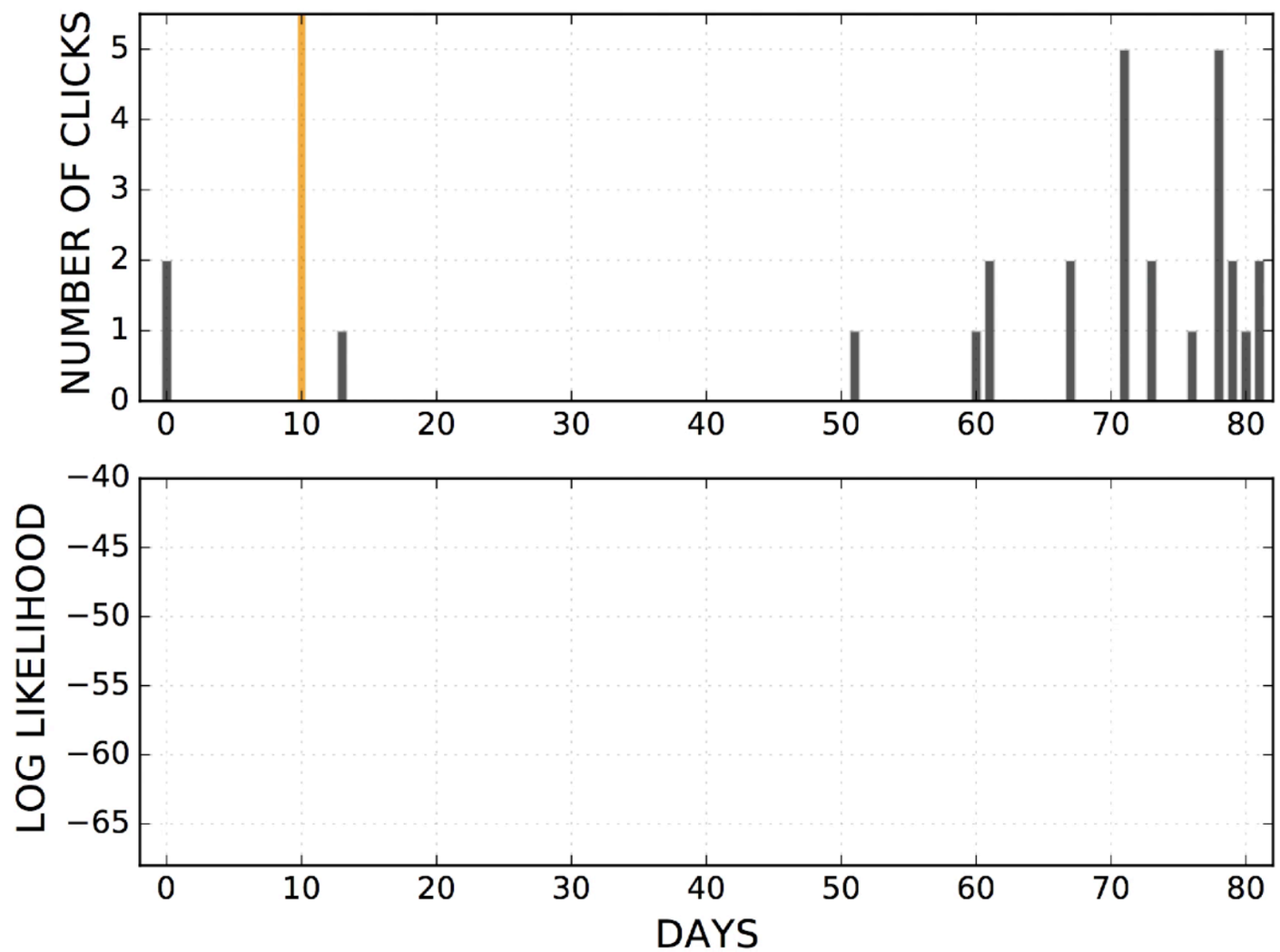


Step2: Model Selection

- Is the **Model with changepoint (M2)** better than the **Model without changepoint (M1)** ?

- **BIC** (Bayesian Information Criterion)
  - Select the model with **smaller BIC**

$$BIC = k\log(n) - 2\log(L)$$

Complexity — Goodness of Fit

L : Likelihood

k : Num parameters

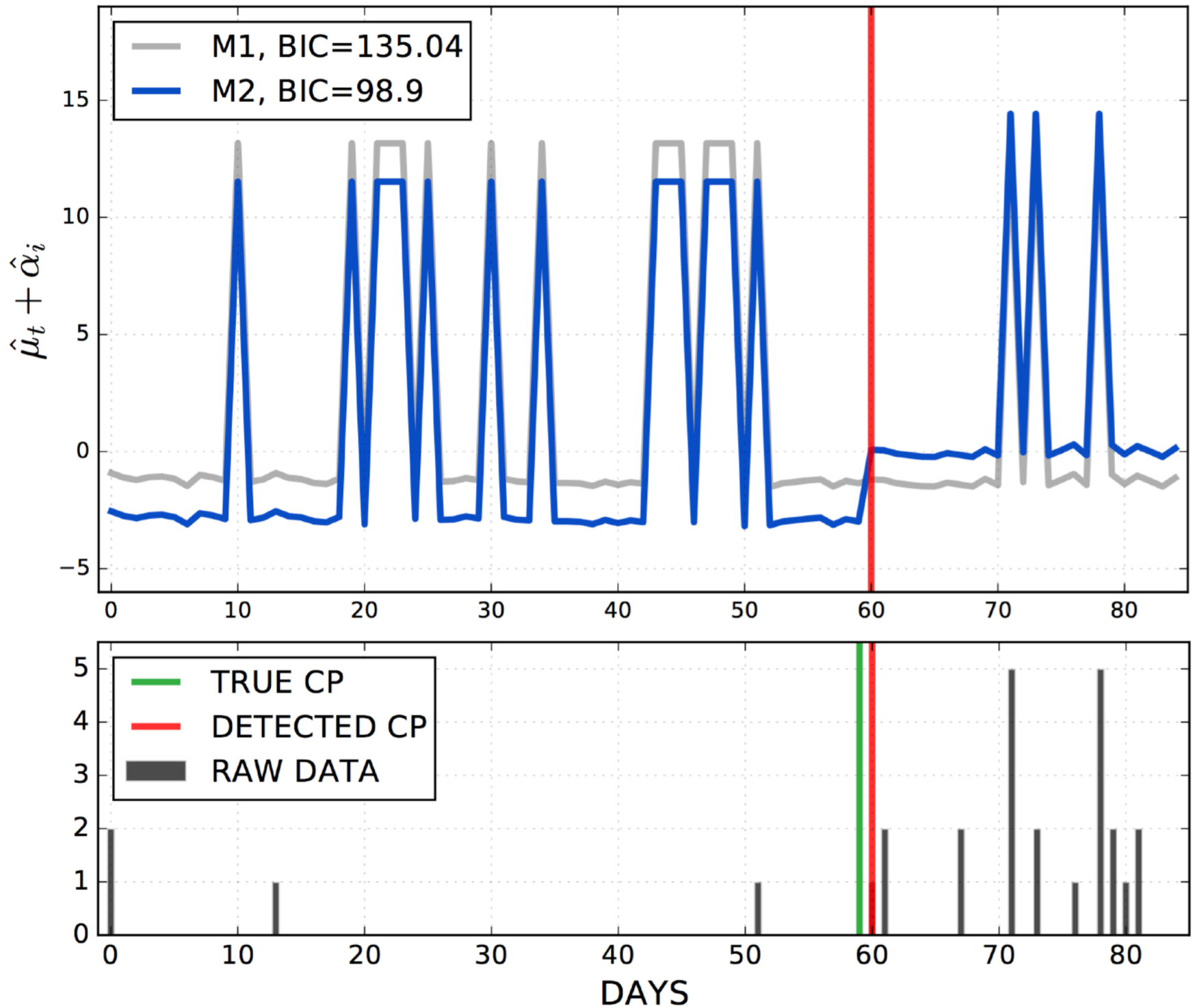
n : Num data points

Step2: Model Selection, BIC

For each student,

Model without the Changepoint		Model with the Changepoint		
BIC_M1	<	BIC_M2	:	Change NOT Detected
BIC_M1	>	BIC_M2	:	Change Detected

Result : Simulated Data



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Data Sets

- 10-week face-to-face course
  - 85 days
  - 377 students
  - 3 midterms
  - Final exam
- 5-week online course
  - 50 days
  - 176 students
  - 25 video lectures
  - Final exam

Data Sets

- 10-week face-to-face course
  - 85 days
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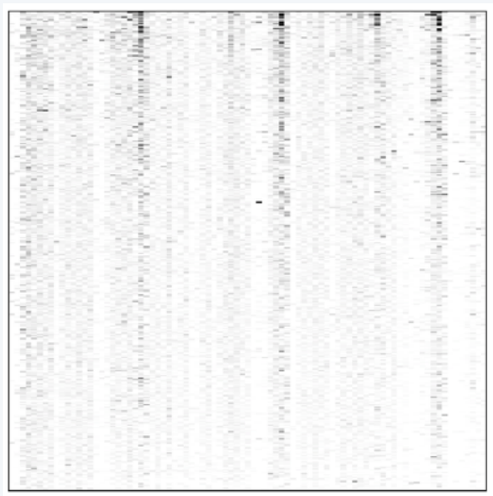
→ **Results are in the paper!**

Preview and Review Behavior

Total Raw Clicks



- Very noisy
- 0 ~ 1115 Clicks
- Unimportant information

File Clicks

- Lecture notes
- Reading materials
- Exam files (mock-up exams, previous exams, etc.)

Preview Clicks

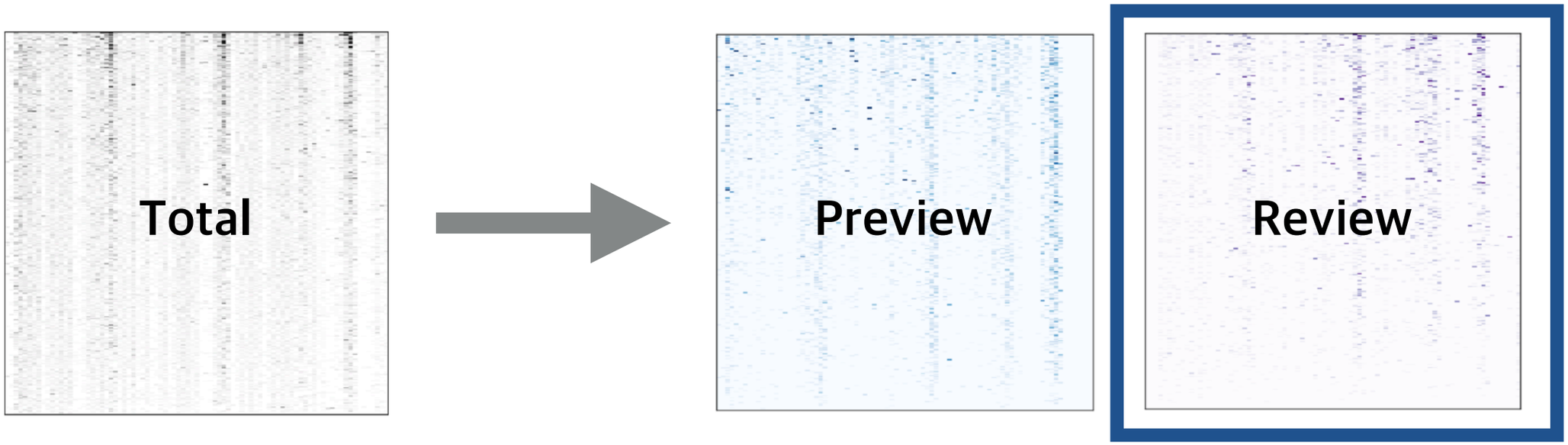
- Opening a file BEFORE the deadline

Review Clicks

- Opening a file AFTER the deadline

Preview and Review Behavior

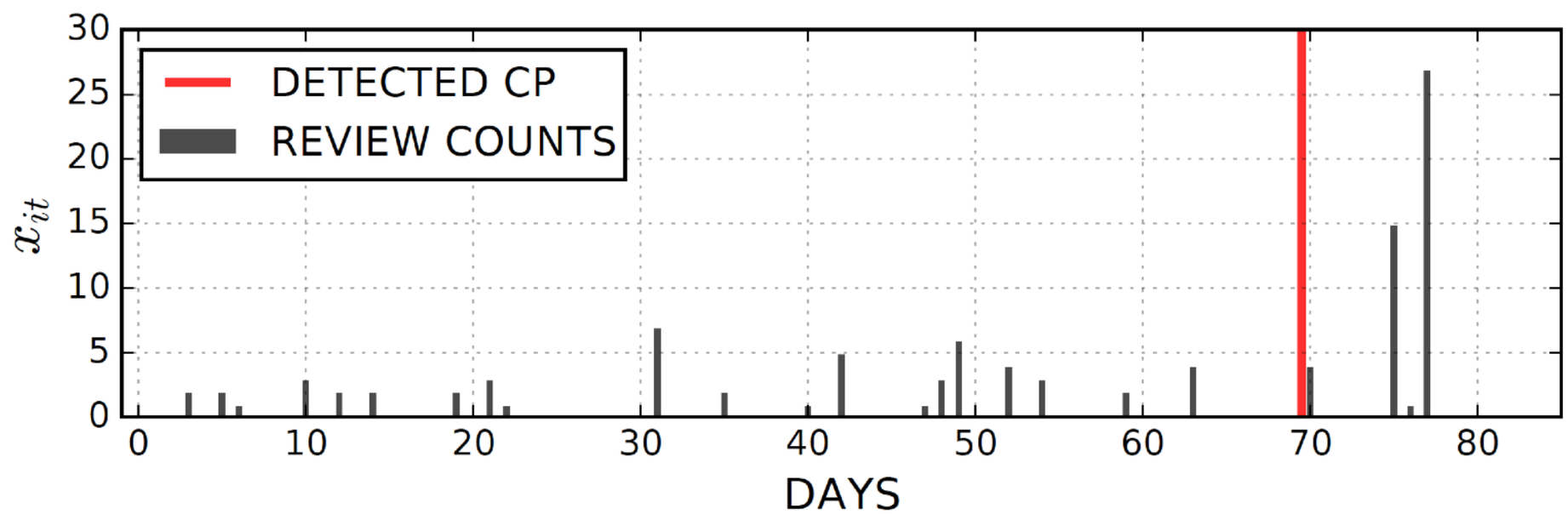
- **Preview (Pre)**
  - Opening a file BEFORE the deadline
  - e.g. opening a lecture note before the lecture starts
- **Review (Post)**
  - Opening a file AFTER the deadline
  - e.g. opening a lecture note after the lecture ends



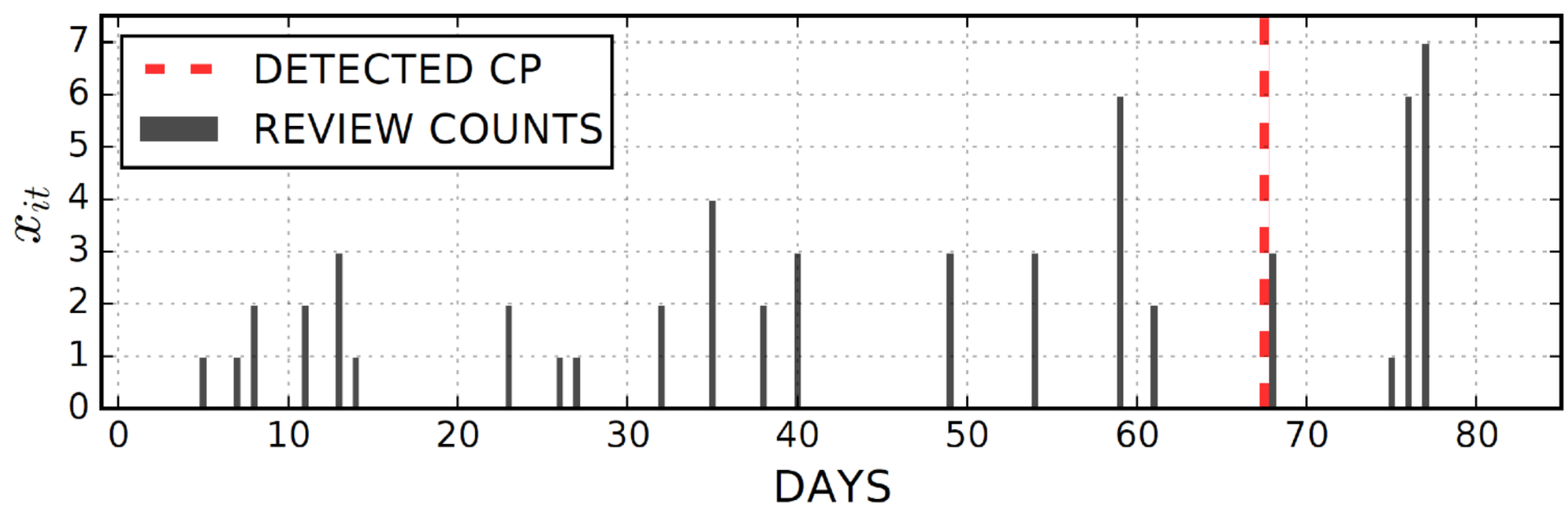
Preview results are in the paper

Example of Two Individual Students

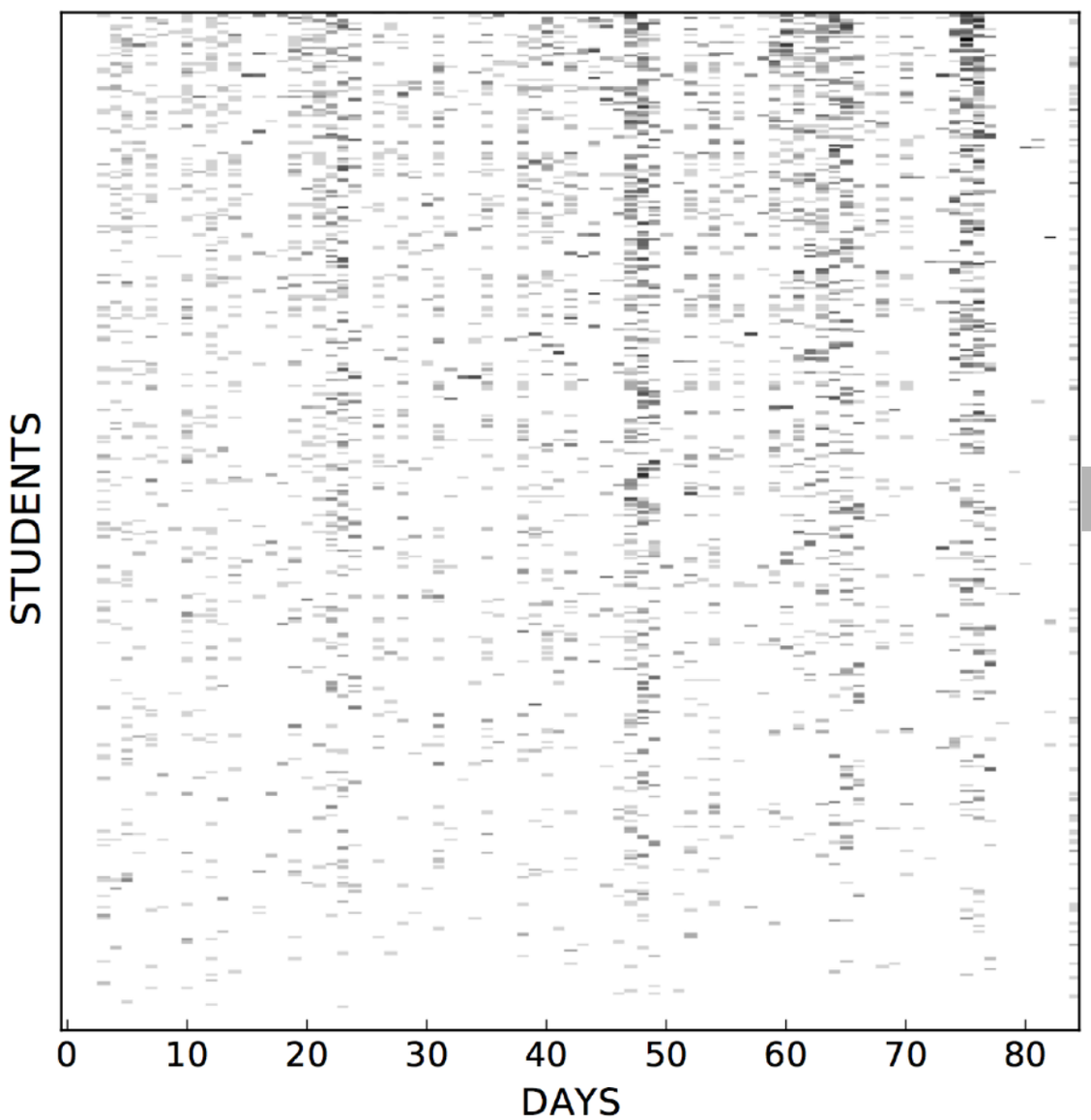
Student with detected change

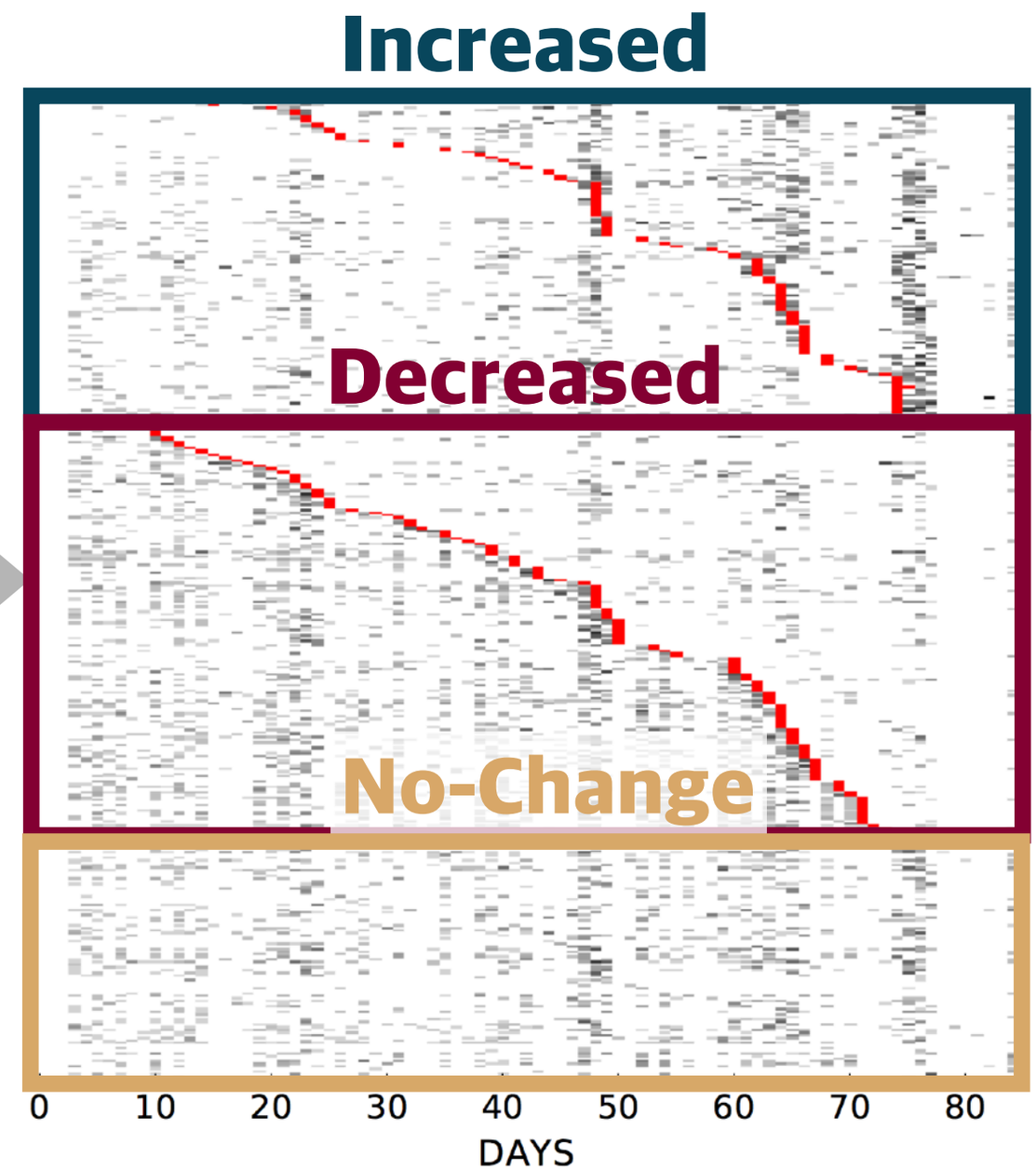


Student without detected change

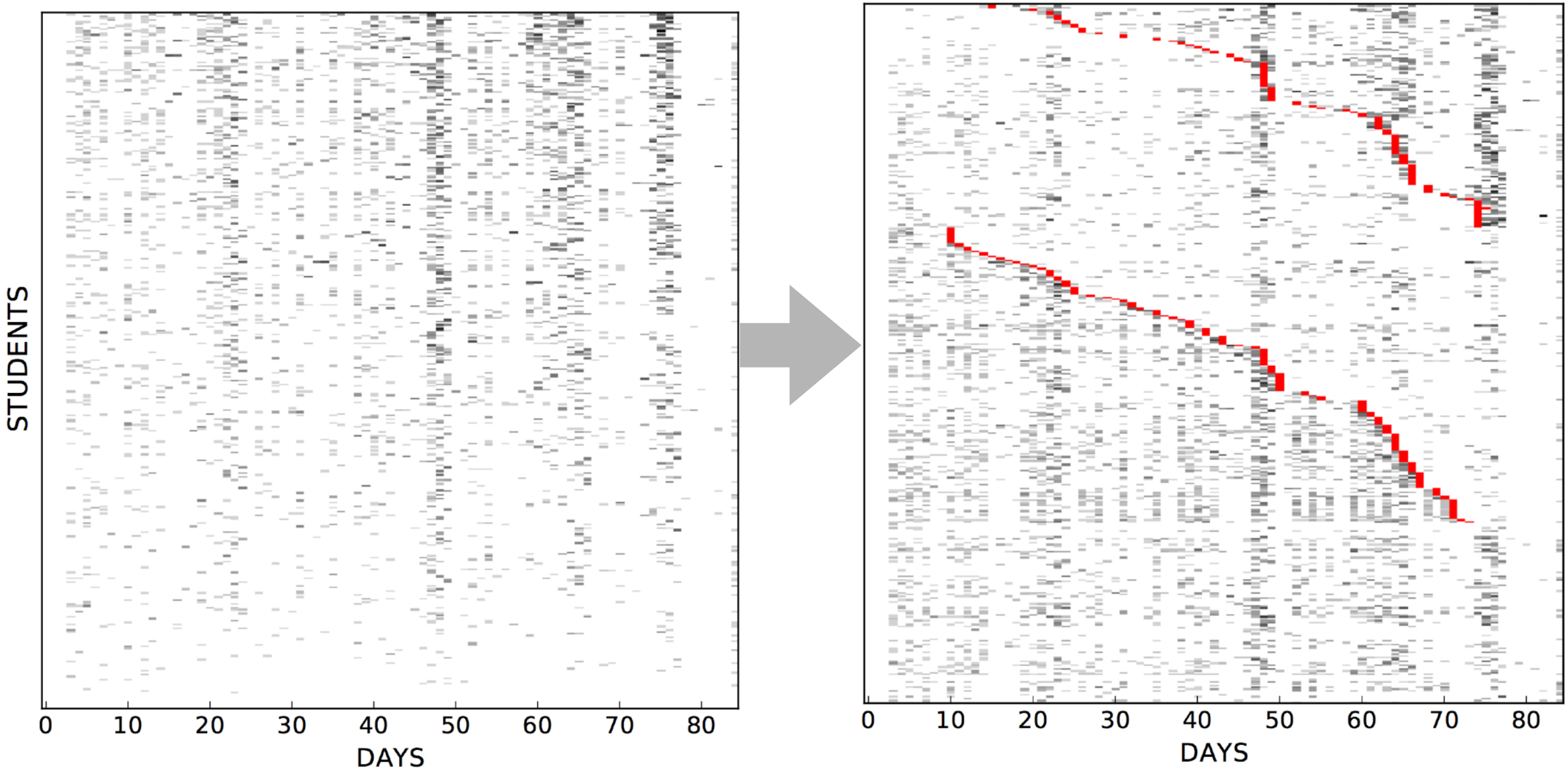


Visualizing Changes in Student Behavior



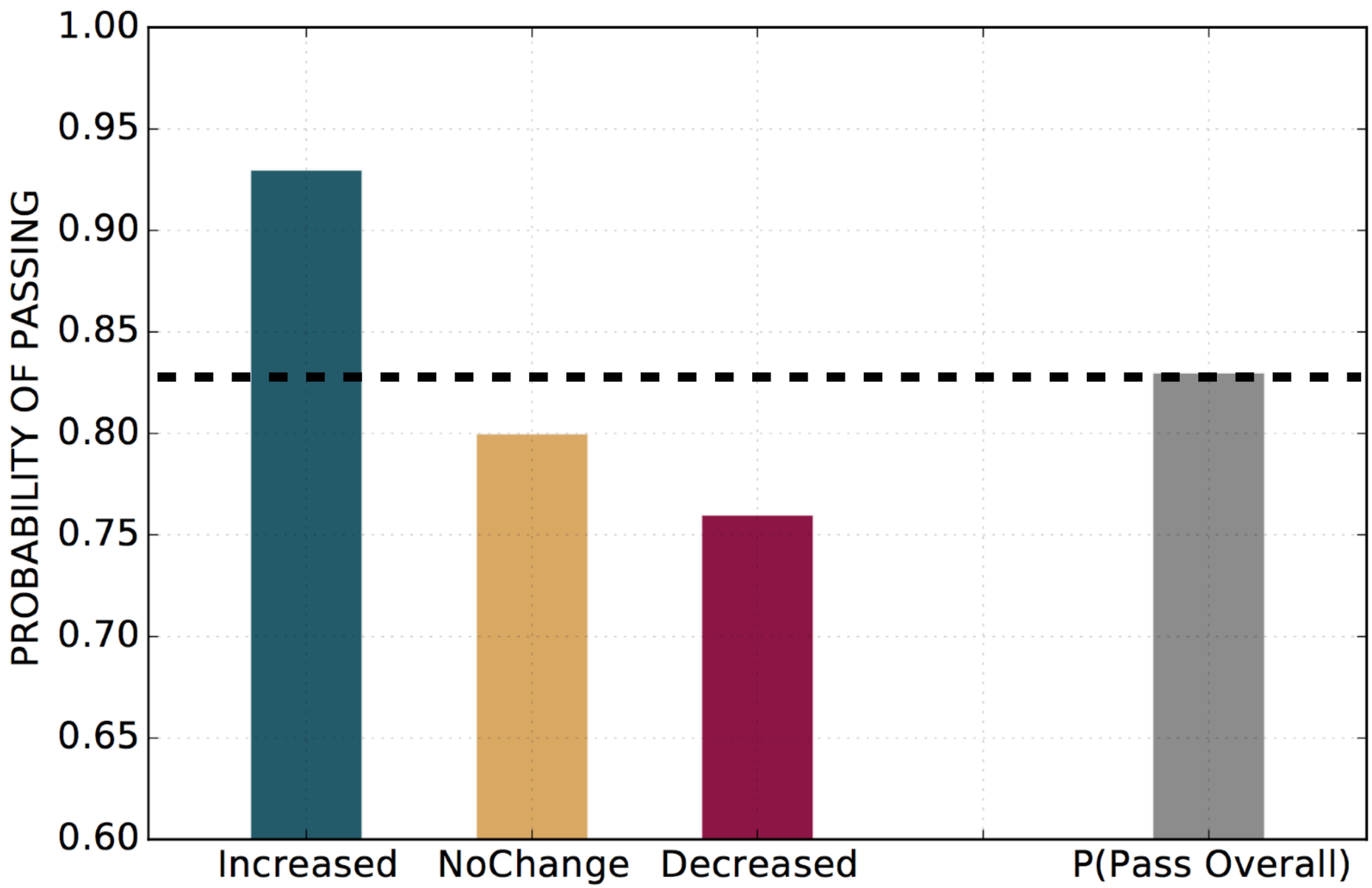


Visualizing Changes in Student Behavior



Student Behavior Change by Grade

- Probability of receiving a passing grade (A, B, C) for Review data



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Summary

- A model for individual student click behavior over time relative to the population of students
- A change-detection method for detecting changes in behavior of individual students
- We were able to
  - Explain individual student's clicking behavior relative to population
  - Relate course engagement with behavior change pattern (increase, decrease)
  - Find relations between behavior change and course outcome

Future Work

- Comparing the same students in multiple courses
- Real-time change detection
- Bayesian models
- Multiple changepoints for longer-term courses
- Python code will be released soon
  - jihyunp@ics.uci.edu

THANK YOU ☺