# Experimental Analysis of Mastery Learning Criteria

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UMAP 2017

# Mastery Learning

- common personalization approach in educational systems
- “practice until mastery, then move to a subsequent topic”

# Example

| item | answer | time | correct? |
|---|---|---|---|
| $\frac{2}{3} + \frac{4}{5}$ | $\frac{13}{15}$ | 12s | correct |
| $\frac{3}{4} + \frac{1}{6}$ | $\frac{10}{12}$ | 7s | incorrect |
| $\frac{2}{7} + \frac{3}{14}$ | $\frac{1}{2}$ | 9s | correct |
| $\frac{1}{4} + \frac{2}{3}$ | $\frac{11}{12}$ | 7s | correct |
| $\frac{2}{5} + \frac{3}{7}$ | $\frac{29}{35}$ | 13s | correct |

Should the learner continue or move to another topic?

# Mastery Criteria

important, interesting, understudied research direction

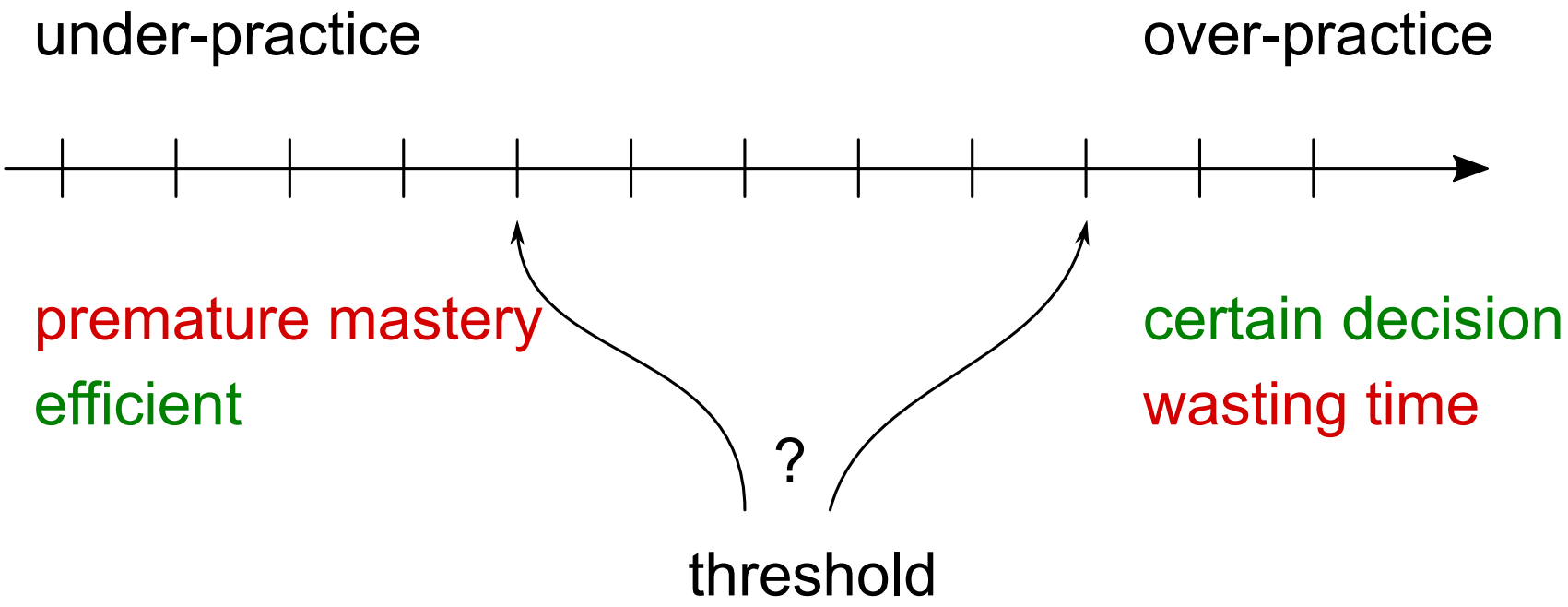
- hard to decide what to use
- easy to change in real systems
- significant impact on users

# Mastery Criteria

- $N$ consecutive correct (NCC)
- moving average
  - moving window
  - exponential moving average (EMA)
- based on learner model – threshold rule
  - Bayesian knowledge tracing (BKT)
  - logistic models

# Evaluation, Thresholds

evaluation difficult, no clear "correct decisions"



# Questions

- Which criterion to use?
- Does the use of learner modeling bring advantage?
- How to evaluate mastery criteria?
- How to choose thresholds?

# Evaluation: Data

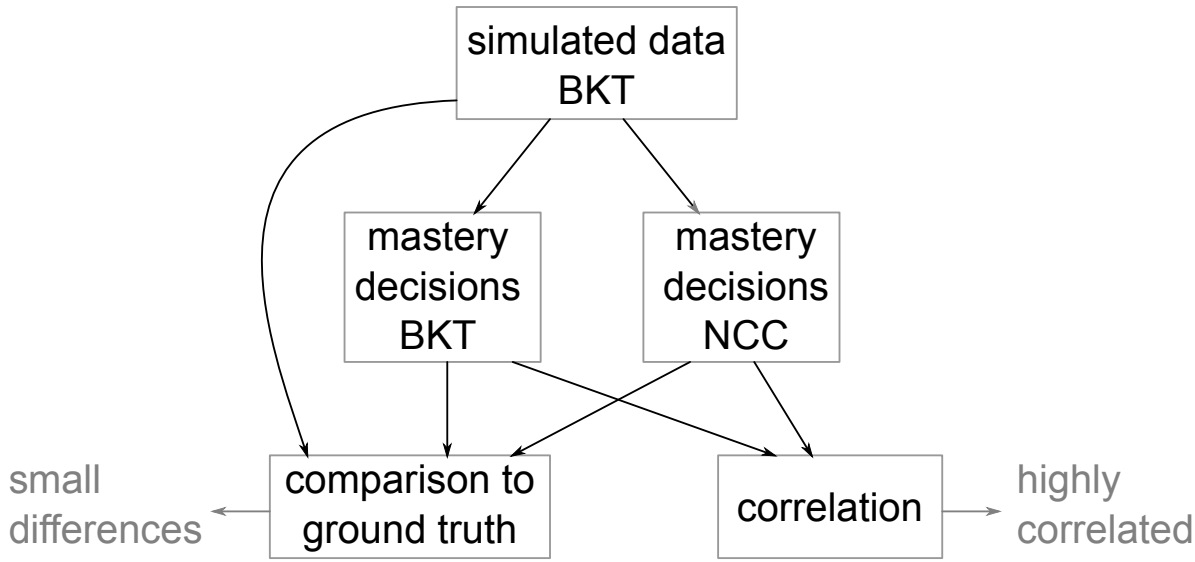
- simulated data
  - simplified
  - ground truth available
- real data
  - realistic
  - difficult evaluation

# Results

- learner models are not fundamental
- the choice of thresholds and input data is more important
- exponential moving average is a convenient approach

# Importance of Learner Models: BKT vs NCC

Bayesian knowledge tracing (BKT) vs N consecutive correct (NCC)




Even under optimistic setting, the learner model does not provide fundamental advantage over a very simple mastery criterion.

# Importance of Learner Models: Input Data

real data (adaptive practice of mathematics)

| | logistic learner model | exponential moving average |
|---|---|---|
| correctness | M1 | M2 |
| correctness + response time | M3 | M4 |

less correlated

highly correlated

# Exponential Moving Average

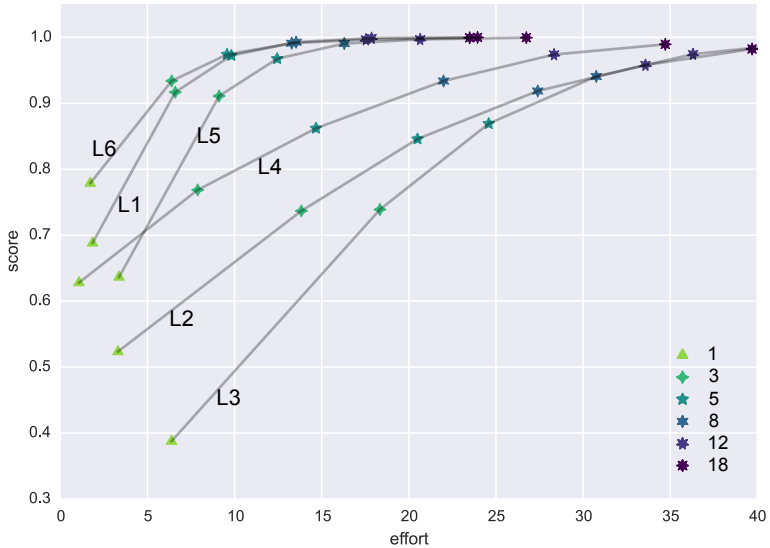
flexible, sufficiently powerful:

- two parameters: decay, threshold
- by tuning these parameters it can fit many circumstances

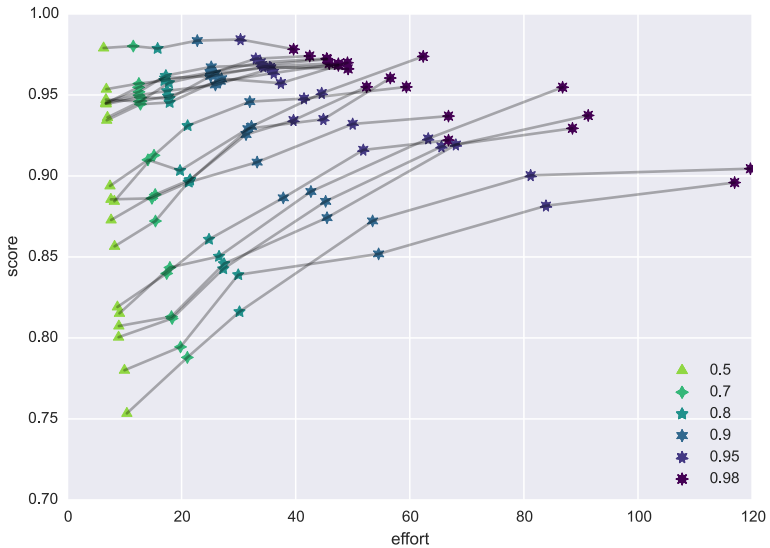
# Effort-score graphs

## Visualizing the trade-off

### NCC for simulated data




### EMA for real data



# Summary and Future Work

Use simple criteria, focus on input data and thresholds, not on models.

limitations and future work:

- multiple knowledge components
- wheel-spinning students
- forgetting
- partial credit