Deploying a Model-based Adaptive Fact-Learning System in a University Course

Rugged Learning

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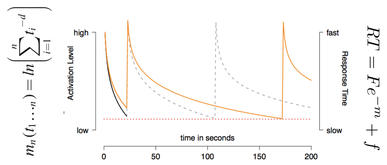
Background

Model / theory

RuggedLearning/SlimStampen is an extended version of Pavlik & Anderson's (2005, 2008) ACT-R-based adaptive fact-learning model. The extended model uses both the accuracy and the latency of a response to estimate the activation of each item. Items are repeated before their activation level drops below the retrieval threshold. The system is designed to optimize *within*-session spacing of repetitions by adapting the internal "rate of forgetting" on a per-item, per-subject level. This optimisation is based on minimizing the mismatch between predicted and observed reaction times.

The ACT-R model

$$m_n(t_1 \ldots_n) = ln\left(\sum_{i=1}^{n} t_i^{-d}\right)$$



$$RT = Fe^{-m} + f$$

$$d_{i,n} = c \times e^{m_i(t_{n-1})} + \alpha_i$$

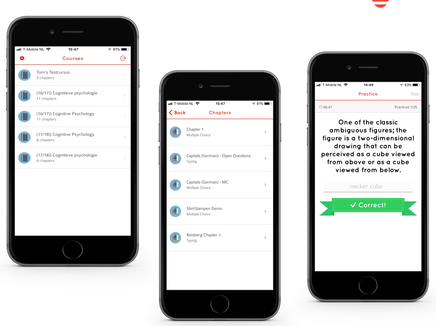
rate with which m_i decreases over time

activation m_i on the previous trial

learning parameter alpha

After validating this system in several well-controlled lab studies, this work reports on deploying the system as an app in a university course, allowing students to study in realistic circumstances at their convenience.

The App



The study material was made available through the BlackBoard environment. Students could use their web browser or an iOS/Android app to access the material any time.

Using the app was optional. Material was made available chapter-by-chapter.

Try yourself at https://**app.slimstampen.nl**/

Sample

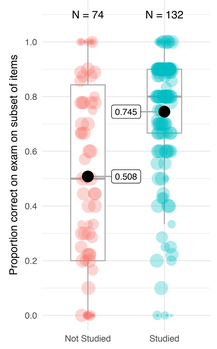
Cognitive Psychology is a third-year elective course in the Psychology undergraduate program at the University of Groningen. In the 2017/18 cohort, students could study relevant material from each chapter in the textbook using the Rugged Learning system.

Complete sample:	**Data used:**
338 enrolled students	156 students gave consent (46.2%)
286 took the exam	147 took the exam (51.4%)
269 used the system	138 used the system (51.3%)
456,099 recorded trials	262,978 recorded trials (56.7%)

The final exam contained 10 open questions chosen from the Rugged Learning item set.

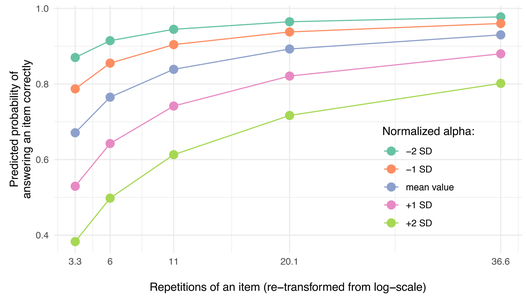
Does it work?

Item-level exam performance



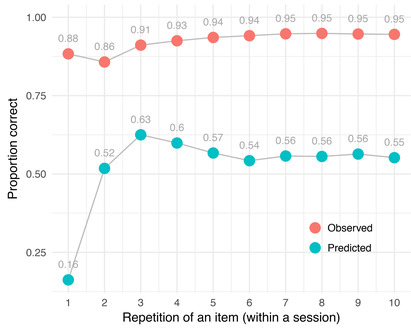
Items that were seen at least once are answered correctly on the exam more often.

Seeing an item more often increases the probability of answering it correctly on the exam. And so does the model's latest estimate of someone's rate of forgetting.



Model predictions vs. actual behavior

Response accuracy



Overall, 90% of observed responses were correct but only 45% of responses were predicted to be correct.

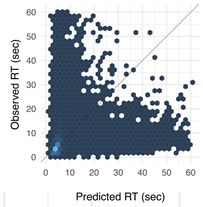
This effect is especially pronounced for the first time an item is seen in a session: 16% of responses are predicted to be correct but 88% are.

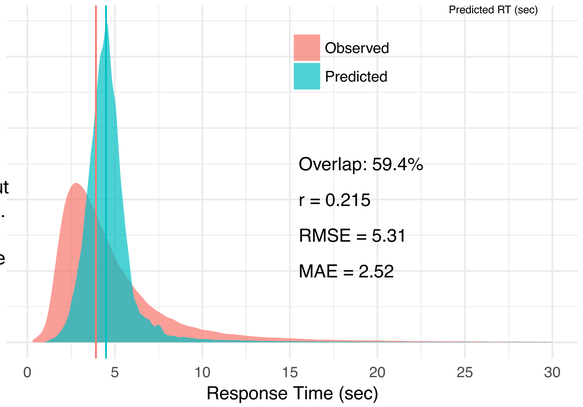
This suggests the model severely under-predicts learners' accuracy/an item's activation.

Response latency

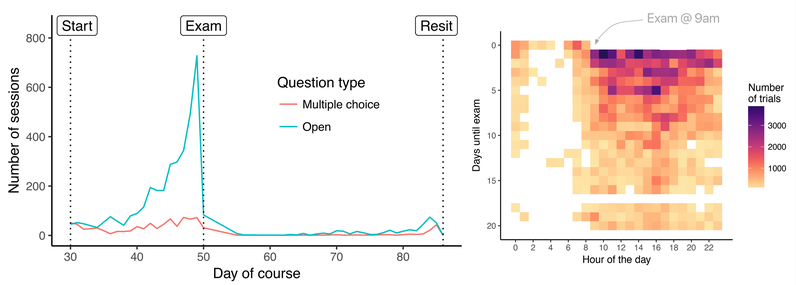
Predicted and observed latencies match relatively well.

The shapes of the two distribution differ, though.

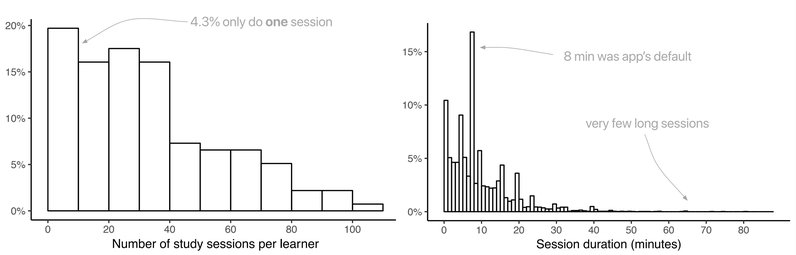




When and how is it used?



Students mostly study right before the exam. 16.9% of sessions are on the last day.



Conclusions

- Items studied with the adaptive system are more likely to be answered correctly on the exam. Repeating items more often during practice makes recall on the exam more likely. Estimated model parameters also predict item-level exam performance.

- Students tend to mass rather than space their practice sessions. Usage of the system ramps up just before the exam.

- Study sessions are usually rather short. Students tend to finish the sessions they start.

- The model underestimates the activation of items. Especially when time elapses between sessions.

- Students prefer to practice with open questions rather than multiple choice questions. Students knew that questions on the exam would be open.

More information?
See https://github.com/VanRijnLab/cogpsych-poster for all details.
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