Manipulating Spacing via Opportunistic Study

Our goal is to create an opportunistic tutoring system that leverages the spacing effect and adapts to individual students and individual study items.

- Students using the system can study when and however much they like.
- The system attempts to maximize expected recall at test for a set of study items.
- The only action it can take is to decide which item to present to a student when they need one for study — i.e., when the opportunity arises.
- The choice of which items to present to a student at login gives some control over the ISIs.

Predicting Recall at Test Knowing the Study Schedule

- The Multiscale Context Model (MCM) is a neural network-like model of the spacing effect.
- It provides us with the likelihood $P(M\mid N_{0s}, F_0, M_0, H_0)$.

Modeling Recall at Test Under Uncertainty

To compute the utility $U_i$ of selecting item $i$ for student $s$, we need to model recall probability at test given our observations to date:

$$U_i = P(R_i\mid N_{0s} = 1, H_i) = P(R_i\mid N_{0s} = 0, H_i)$$

$$P(R_i\mid N_{0s}, H_i) = \sum_{i=1}^{k} P(F_i \mid H_i) P(R_i \mid N_{0s}, F_i, M_i, H_i) P(M_i \mid H_i)$$

**Known:**
- $H_i$: $s$’s observed study history (i.e., when they logged in, what they recalled, etc.)
- $N_{0s}$: system’s choice of whether to present $i$ to $s$ now

**Unknown:**
- $R_i$: whether item $i$ will be recalled at test by $s$
- $F_i$: how much and when $s$ will study in the future
- $M_i$: parameters of a memory model

- The system is adaptive in the sense that the recall predictions are conditioned on a student’s past usage and performance
- Assumes item independence

Evaluation

Computer Simulations
- In a series of computer simulations, we assume each student-item pair is characterized by some unknown $M_i$.
- If MCM is a “perfect” model of memory, is our utility-based scheduling method better than alternatives? Yes?
- Does accounting for future study help? Yes?

Empirical Evaluation
- We have begun an experiment with an upper-level Spanish class at CU
- The experiment is synched with the course: students study vocabulary from whichever chapter is currently being covered
- Students take an online quiz following their in-class quiz
- Comparing our scheduler vs. a “round-robin” scheduler and a “worst-first” scheduler (within-subject comparison)
- Comparing students who receive graphs of our predictions against those who don’t

- Does providing quantitative advice to students about the benefits of their studying encourage participation?