Adaptively Adding Concepts During Study Improves Flashcard-based Learning

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INTRODUCTION
Most students use flashcards to study, but they often do not use them effectively (e.g., students drop cards from study too soon; Kornell & Bjork, 2008). Adaptive technology can avoid this by adding or dropping cards based on objective performance criteria.

In this study, we examined the optimal adaptive flashcard learning strategy by having participants identify butterfly species under different adaptive mastery conditions that added or dropped cards based on performance.

HYPOTHESIS
We hypothesized that adding cards as performance improves (Mastery Add) would show better retention and transfer compared to a condition that drops cards (Mastery Drop) or a control condition in which no cards are added or dropped because it lessens the cognitive load at the beginning of study and increases spacing between items.

METHOD

PARTICIPANTS & DESIGN
Data collected across 2 semesters
54 undergraduate psychology students participated for course credit in the spring (27 returned for session 2)
26 students participated in the summer (25 returned)
Participants randomly assigned to one of 3 training conditions
Evaluated on short- and long-term retention (immediate vs. 1 week later) as well as transfer (identify new images of trained categories)

METHOD CONT’D

STIMULI & PROCEDURE
Online butterfly species identification task
- Studied 6 species, with 8 pictures of each
- Given feedback on performance

TRAINING TASK
Participants selected the image showing indicated species
Participants received immediate feedback on their answer

RESULTS

PRE-POST GAIN SCORES
- Mastery Drop shows worst gains from pre to post test
- Mastery Add and No Add/Drop are roughly equal in performance, however Mastery Add completed significantly fewer trials indicating higher efficiency
- Mastery Add shows least amount of forgetting from session 1 to session 2

TRANSFER TEST SCORES
- Evidence of transfer to novel images, suggesting training was effective
- Some evidence for long-term improvement from session 1 to session 2 for Mastery Add
- Suggests adaptively dropping cards from study is less optimal compared to adaptively adding them or keeping all cards in the deck

RESULTS CONT’D

LONG-TERM RETENTION
- Mastery Add shows best retention from session 1 to session 2
- No Add/Drop shows worst overall retention after having the highest immediate post-test scores
- Suggests adaptive mastery can improve long-term outcomes over non-adaptive strategies when concepts are added to the study deck

DISCUSSION
We predicted adaptively adding cards based on performance would improve learning and our data mostly support this hypothesis.
- Mastery Drop performed worse overall
- Mastery Add has similar immediate recall scores as No Add/Drop but shows better delayed recall in long-term retention scores
- All conditions show ability to transfer knowledge, but No Add/Drop shows the most forgetting
- Our results are consistent with the spacing effect literature, showing better long-term retention with increased spacing during learning (i.e., Mastery Add)
- These results have implications for students and instructors in terms of how to best use flashcards for study.

- Students should use adaptive strategies
- Students should consider starting with fewer concepts, then add as they improve