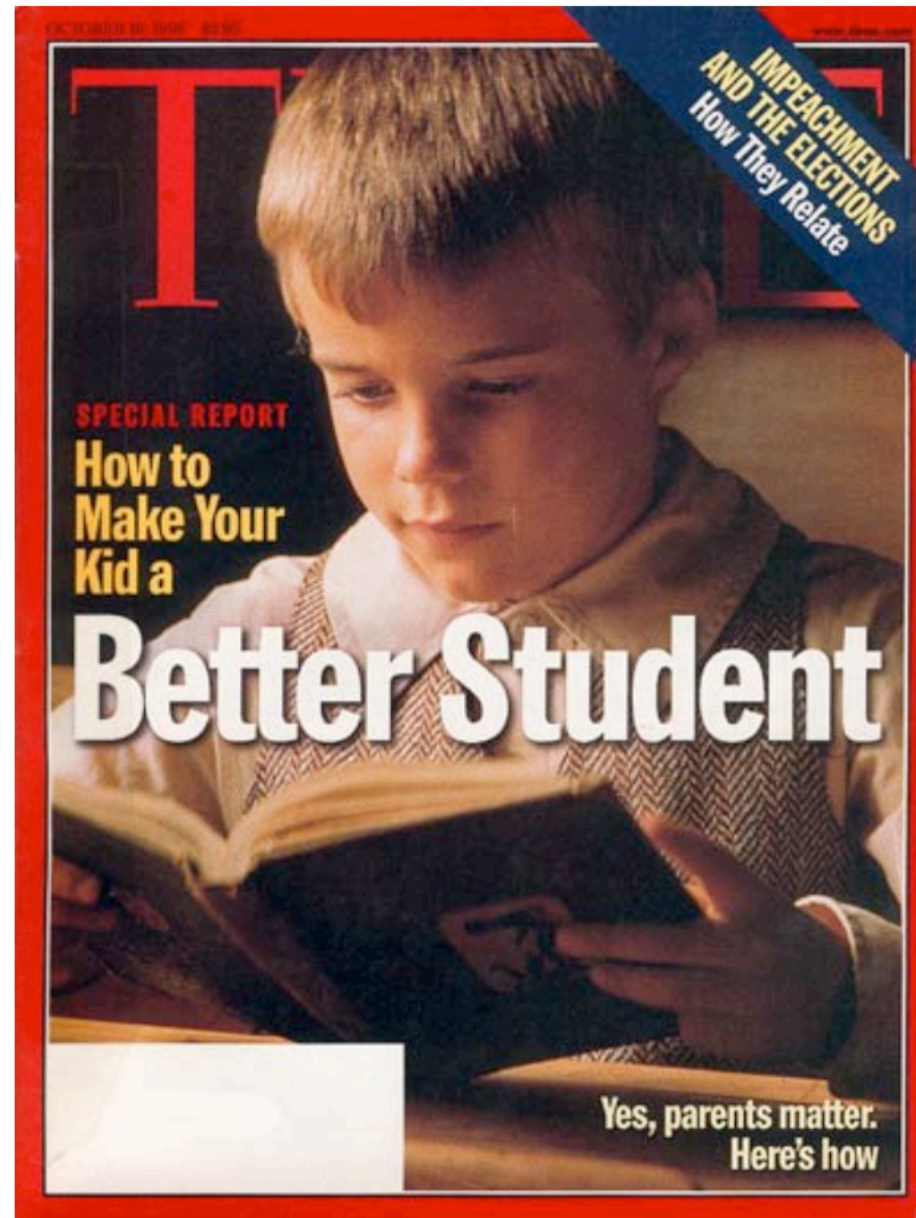


Lab in Cognition and Perception

How to Be a Better Student (using Cognitive Science!)

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How to be a better student



Spacing versus distributed learning

Information is better encoded when there is a longer delay between repetitions (**spaced practice**)

Cramming for a test (**massed practice**) is not a good strategy. Your time is more efficiently spent spacing student sessions over multiple days.

Spacing versus distributed learning

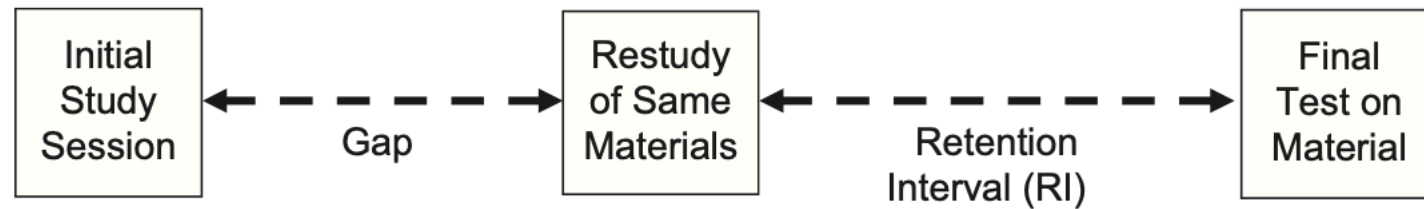
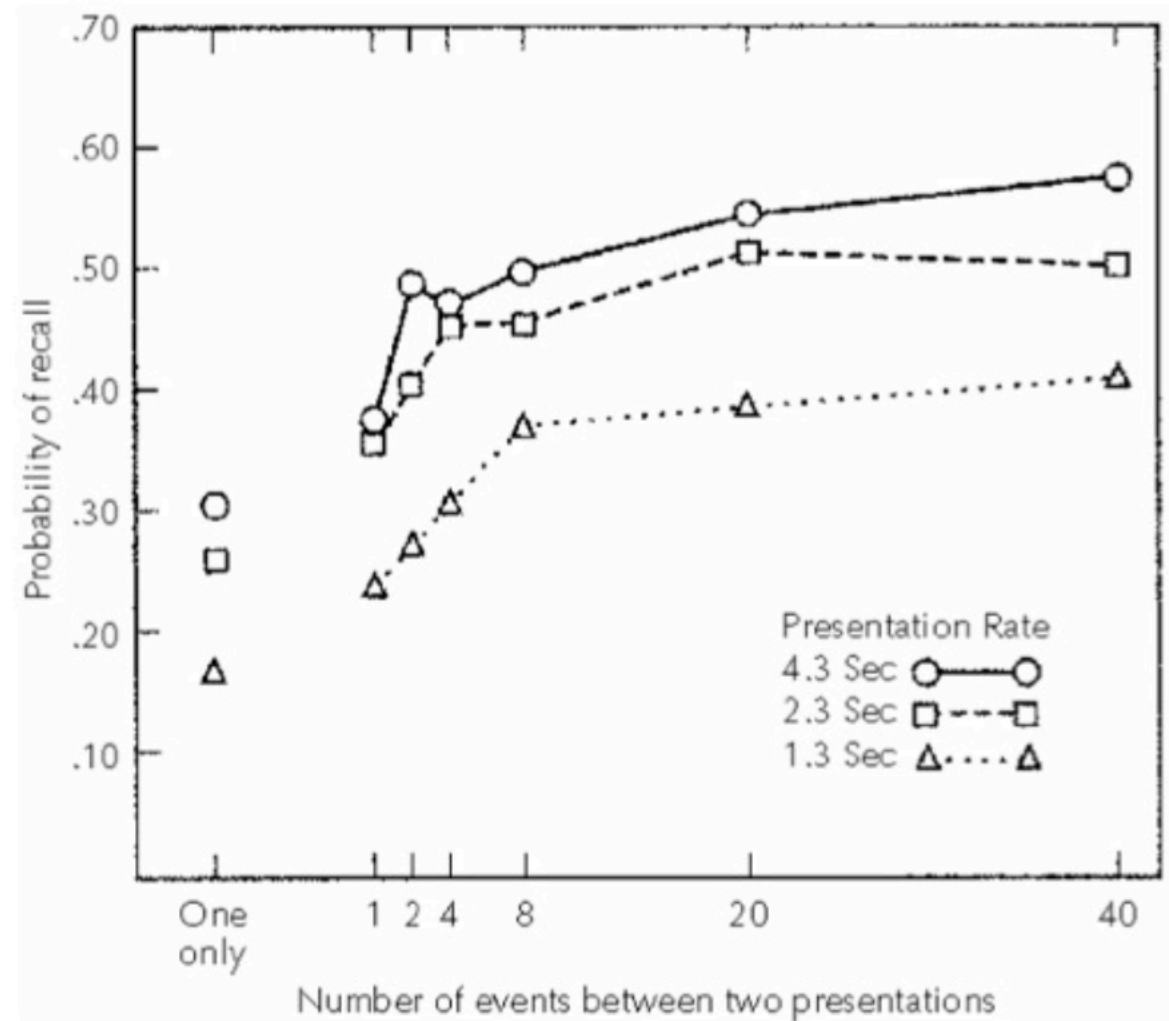


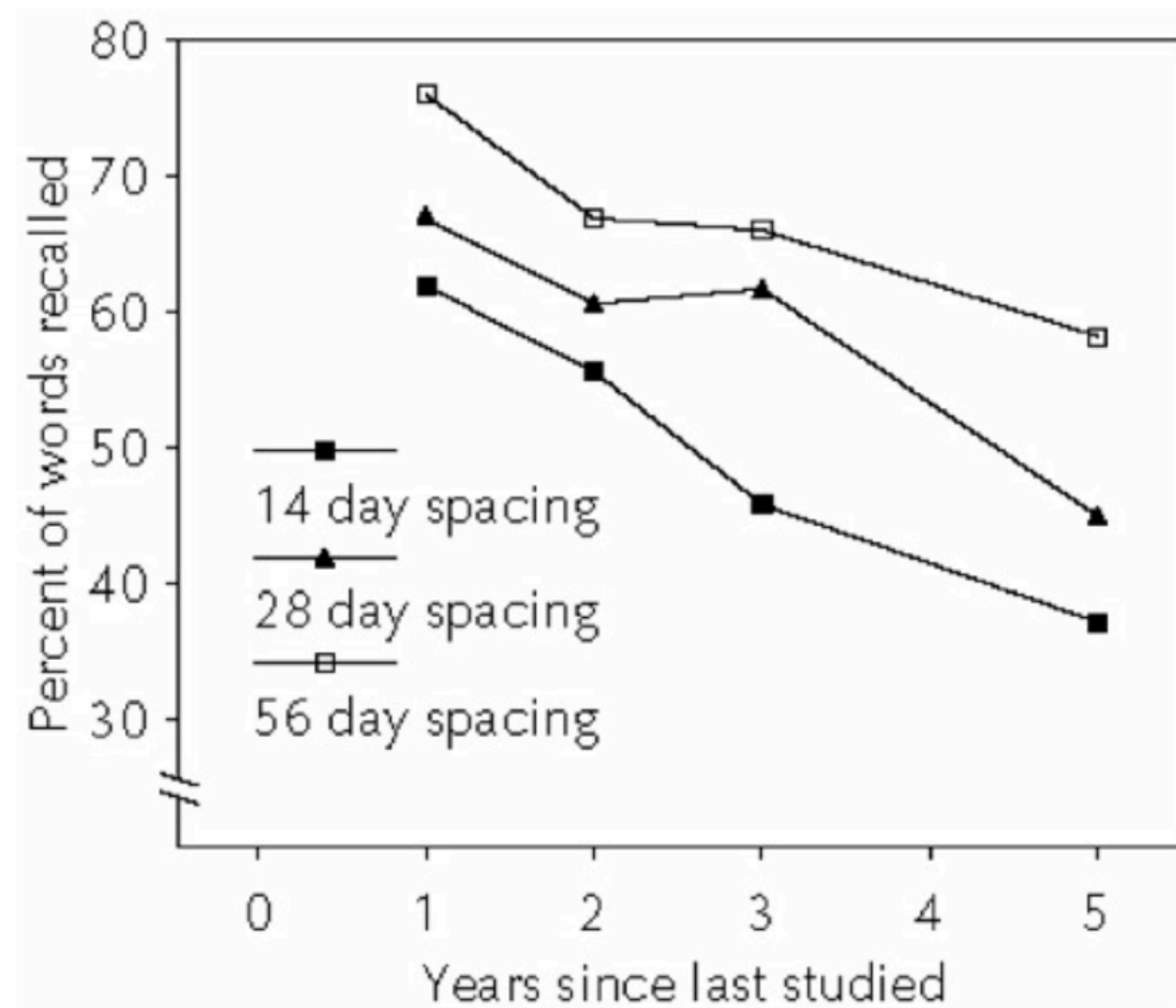
Fig. 1. Structure of a typical study of spacing effects on learning. Study episodes are separated by a varying gap, and the final study episode and test are separated by a fixed retention interval.

- Melton (1970)
- Two repetitions of words spaced apart with different numbers of words presented between them
- Also varied speed of presentation



Spacing versus distributed learning

- Bahrick et al. (1993)
- How long the spacing effect lasts
- Subjects studied foreign vocabulary words every 12, 28, or 56 days for up to 4 years; each subject had same number of repetitions
- Memory tested over next 5 years



Bahrick, H.P., Bahrick, L.E., Bahrick, A.S., & Bahrick, P.E. (1993). Maintenance of foreign language vocabulary and the spacing effect. *Psychological Science*, 4, 316–321.

Spacing versus distributed learning

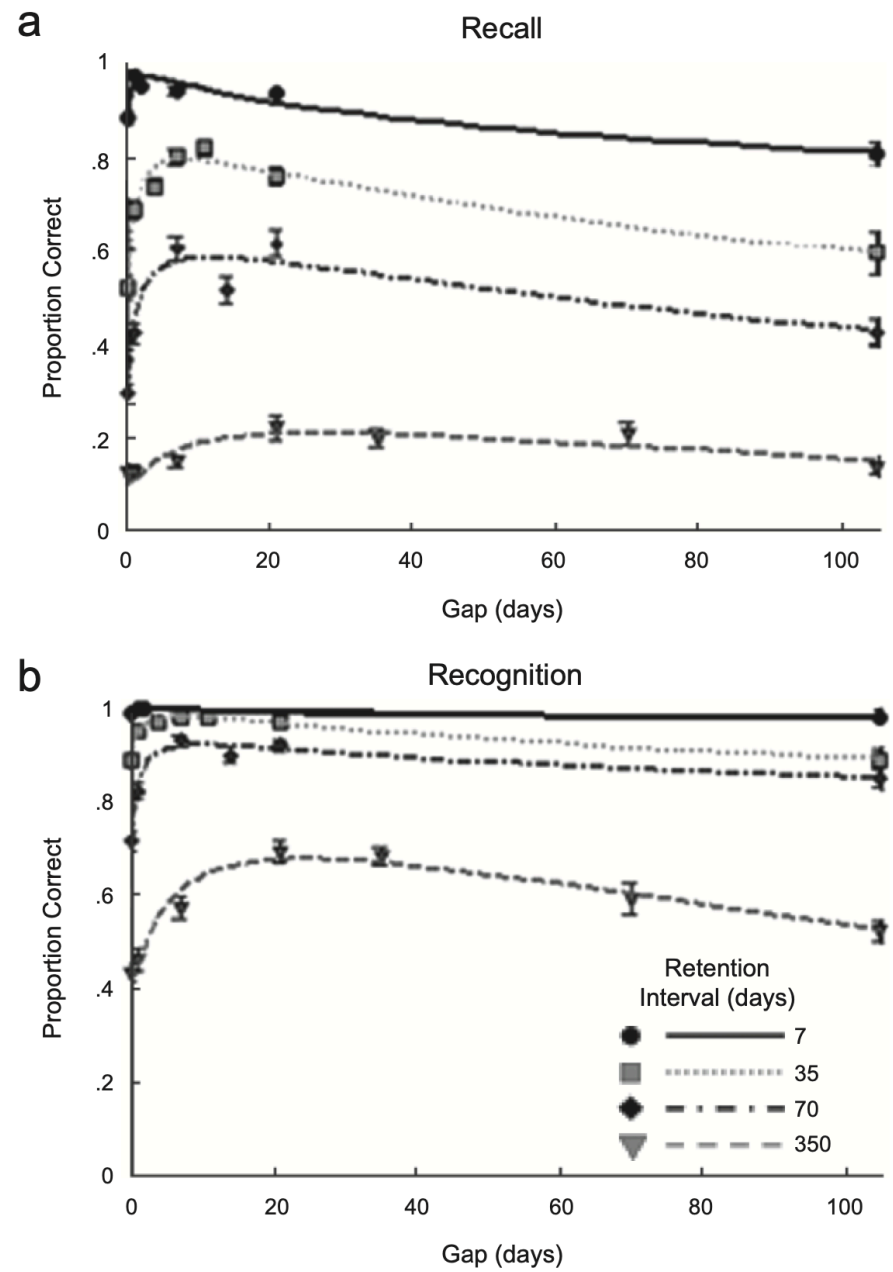


Fig. 3. Performance on the final (a) recall and (b) recognition tests as a function of gap, for each of the four retention intervals. The plotted points show mean accuracy \pm 1 SEM. The lines correspond to cubic spline fits to the data, with fixed points at gaps of 0 and 105 days.

Cepeda NJ, Vul E, Rohrer D, Wixted JT, Pashler H. Spacing effects in learning: a temporal ridgeline of optimal retention. Psychol Sci. 2008 Nov;19(11):1095-102. doi: 10.1111/j.1467-9280.2008.02209.x. PMID: 19076480.

Spacing versus distributed learning

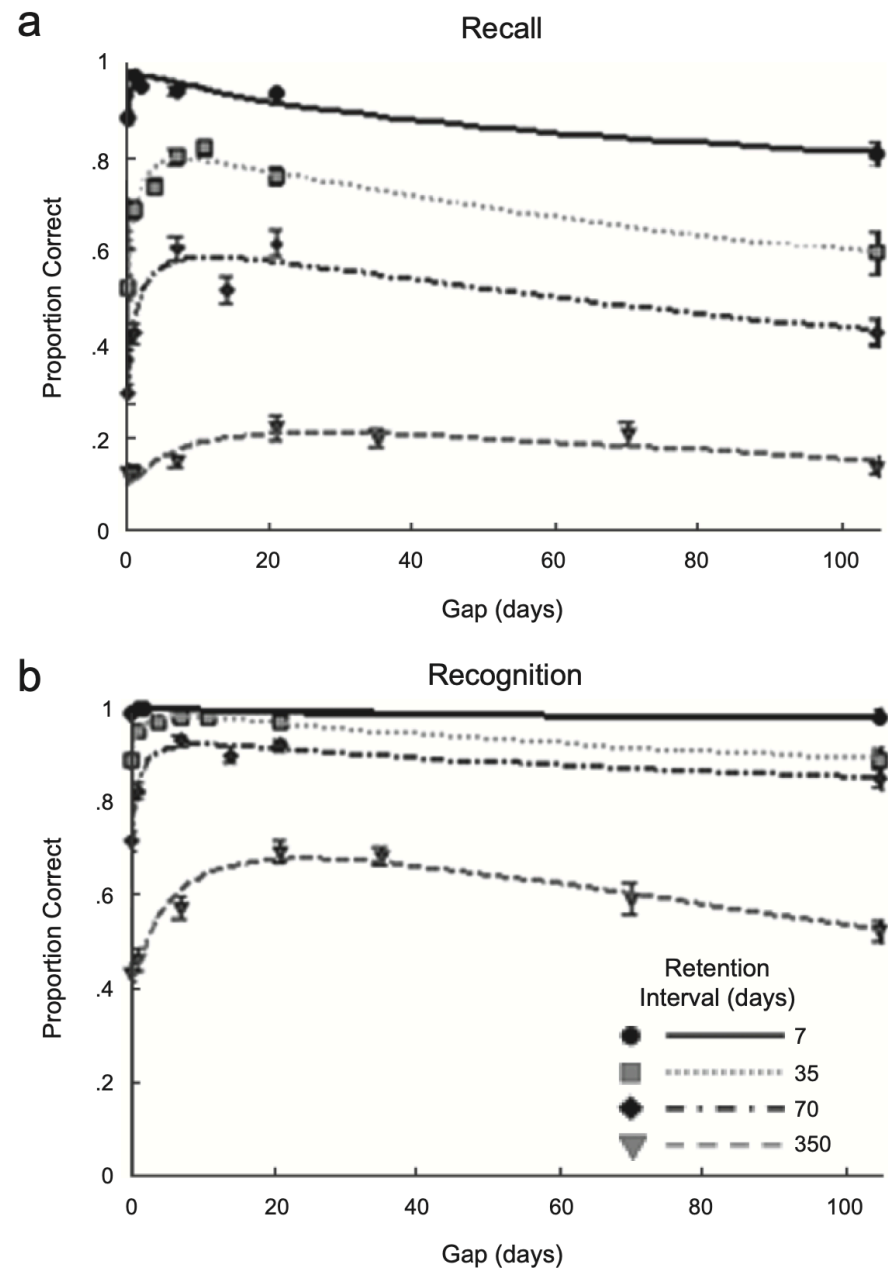


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“Although the interactive effects of gap and RI pose challenges for practical application, certain conclusions can nonetheless be drawn. If a person wishes to retain information for several years, a delayed review of at least several months seems likely to produce a highly favorable return on the time investment— potentially doubling the amount ultimately remembered compared with a less temporally distributed study schedule, with study time equated. Although this advice is in agreement with the earlier work of Bahrick (e.g., Bahrick et al., 1993), it is at odds with many conventional educational practices—for example, study of a single topic being confined within a given week of a course.”

Cepeda NJ, Vul E, Rohrer D, Wixted JT, Pashler H. Spacing effects in learning: a temporal ridgeline of optimal retention. *Psychol Sci.* 2008 Nov;19(11):1095-102. doi: 10.1111/j.1467-9280.2008.02209.x. PMID: 19076480.

Spacing versus distributed learning

- Why is spaced practice better?
- **Encoding variability:** Study sessions that are more distant in time are likely to occur in different contexts making for a richer representation of the memory
- Not just for episodic memory!
- Also improves retention of motor skills like typing, snowboarding, etc..
- but is it good for all types of learning?

Spacing versus distributed learning

Research Article

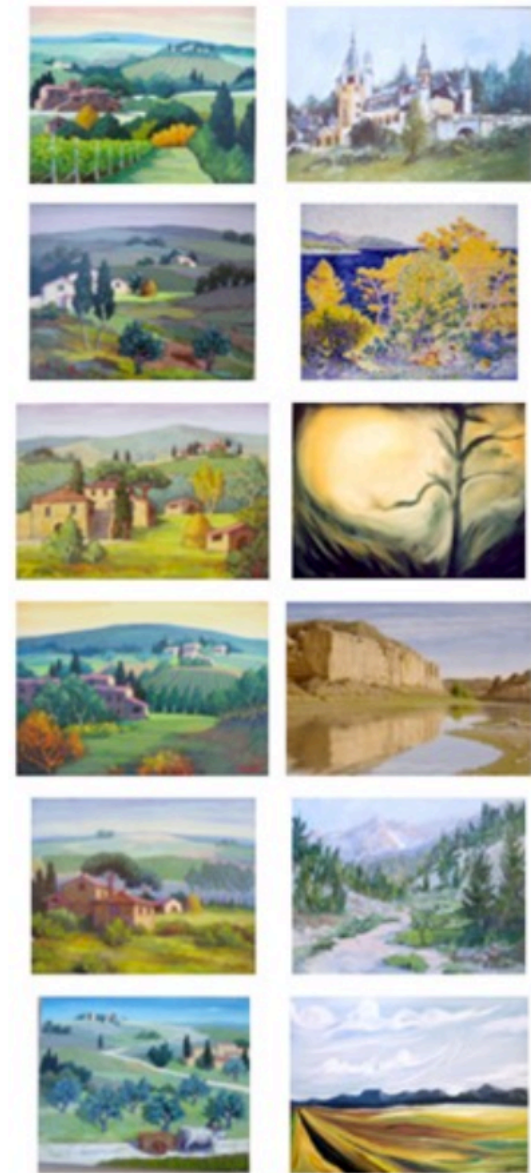
Learning Concepts and Categories

Is Spacing the “Enemy of Induction”?

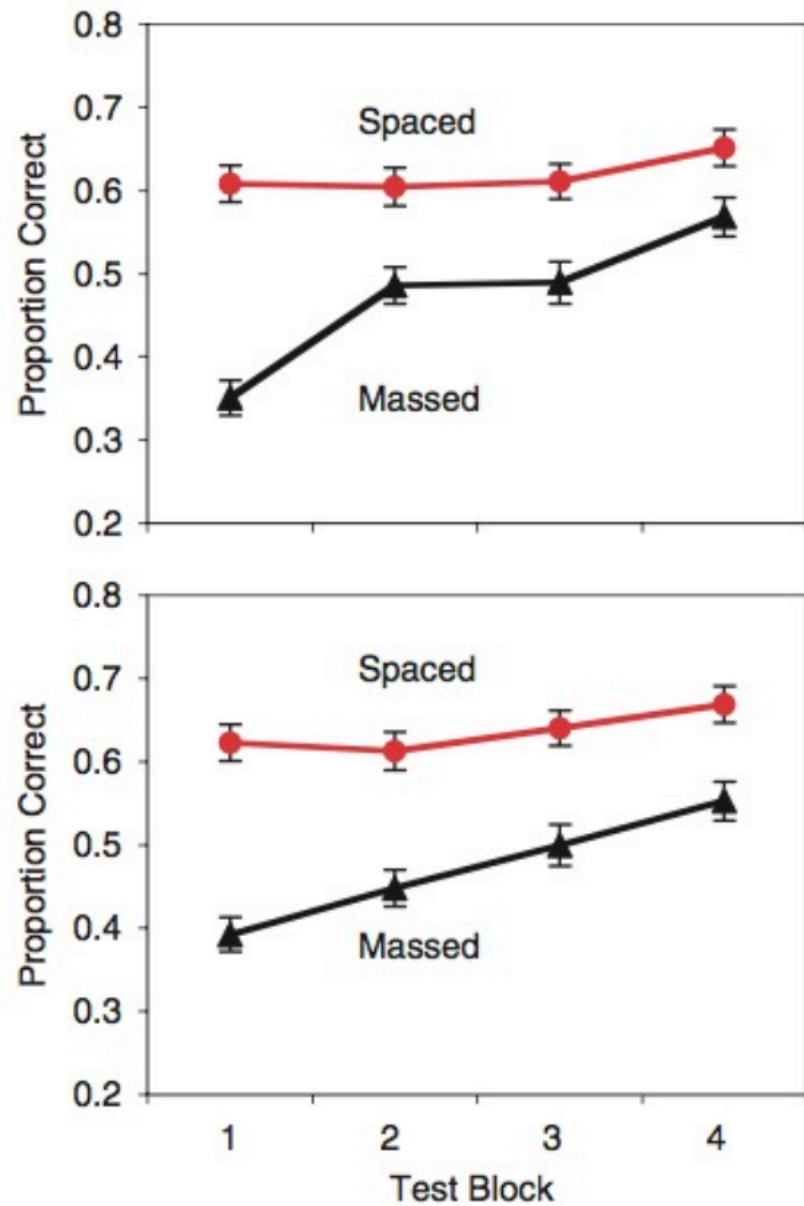
Nate Kornell and Robert A. Bjork

University of California, Los Angeles

Spacing good for memory but might make it harder to detect commonalities if you are extracting a pattern from a set of examples.



Spacing versus distributed learning

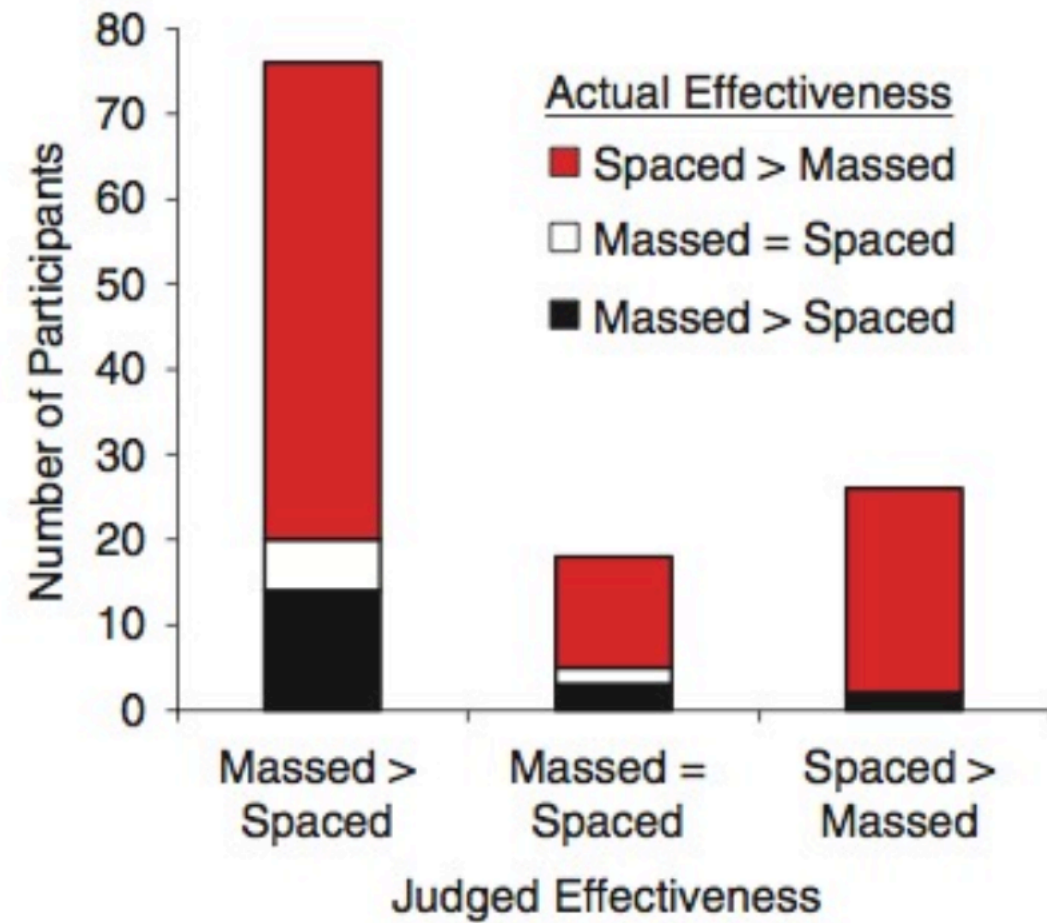
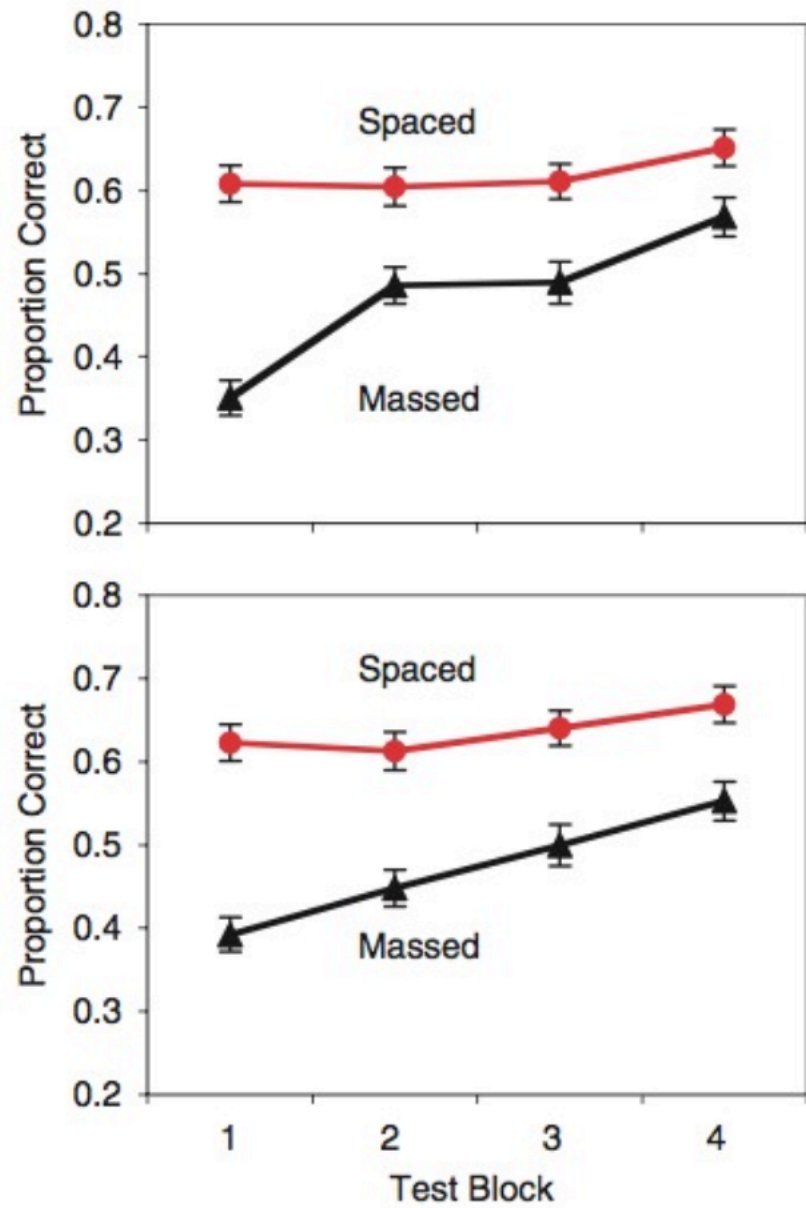


Some items massed/some spaces
MSSMMSSMMSSM

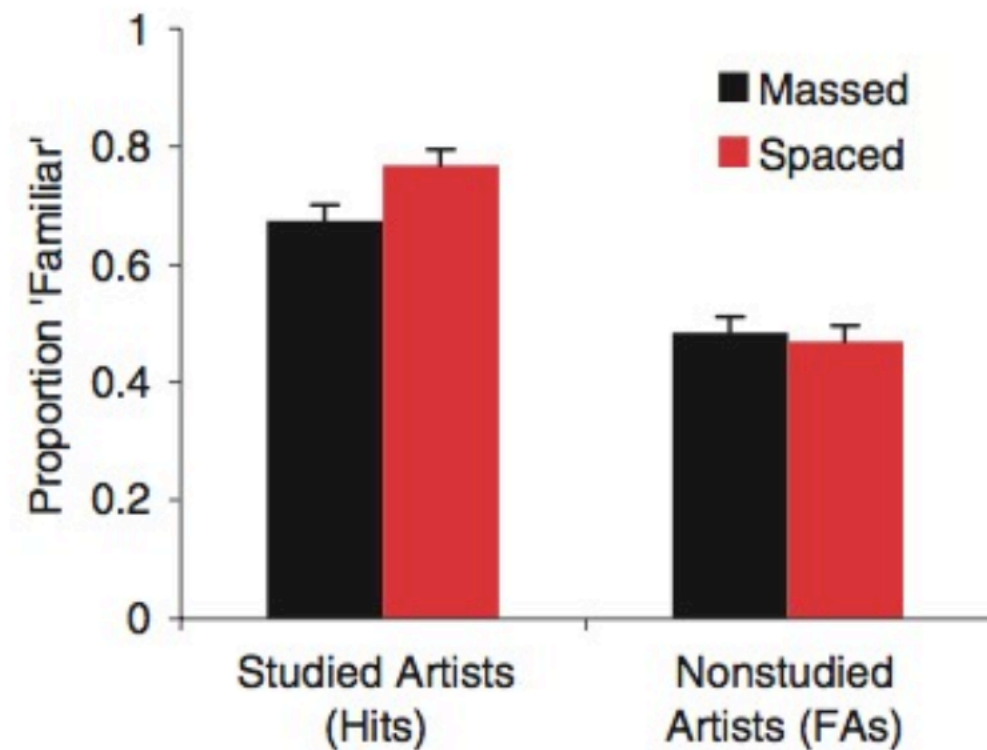
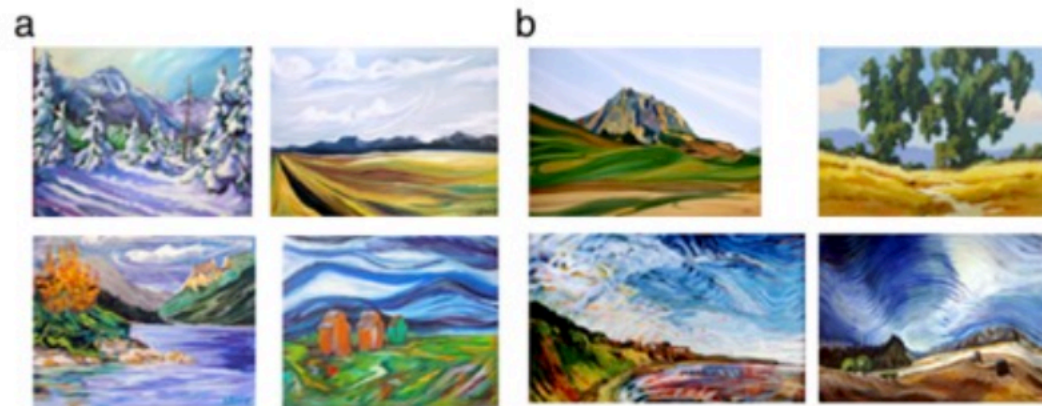
All paintings either space or massed
 depending on condition

Test: classify the painter of a novel
 Painting

Spacing versus distributed learning



Spacing versus distributed learning



Test: recognition (have you seen this artist work in the study phase?)

Spacing versus distributed learning

Key points

- Spacing was *not* the enemy of induction it was previously assumed to be
- People misjudge which conditions they have remembered better. **YOU DON'T UNDERSTAND HOW YOUR OWN MEMORY WORKS!**

Spacing versus distributed learning

- Do people actually prefer to self-study in accord with the spacing effect?
- **NO!** Well, many students cram for tests. This may simply reflect poor time management rather than lack of understanding of spacing effect
- However, experiments show the people rate massed practice as a better way to learn a list (Simon & Bjork), and when given the option prefer massing their practice
- “massing provides a sense of ease, which learners assume will translate to good memory on a later test, whereas spacing is often as ‘desirable difficult’” (Kornell & Bjork, 2008)

Testing (and generation) effect

- Information is better remembered when it is generated by a subject than when it is presented to a subject
- e.g., studying by generating the definitions of terms is more effective than reading the definitions of terms (flashcards)
- Maybe be related to *levels of processing*

Testing (and generation) effect

Slameka & Graf (1978)

- Had subject study pairs of words in two ways:
 - **Read:** subjects saw two words that were related by a rule and were asked to read them (e.g., are the words synonyms?)
 - **Generate:** subject saw one word along with the first letters of another word, were asked to generate a word that has a specific relationship with the first word
 - e.g., opposite HOT-C_____

Testing (and generation) effect

Condition 1 Read

king - crown

horse-saddle

lamp-shade

...

Condition 2 Generate

king - cr_____

horse-sa_____

lamp-sh_____

...

Cued Recall

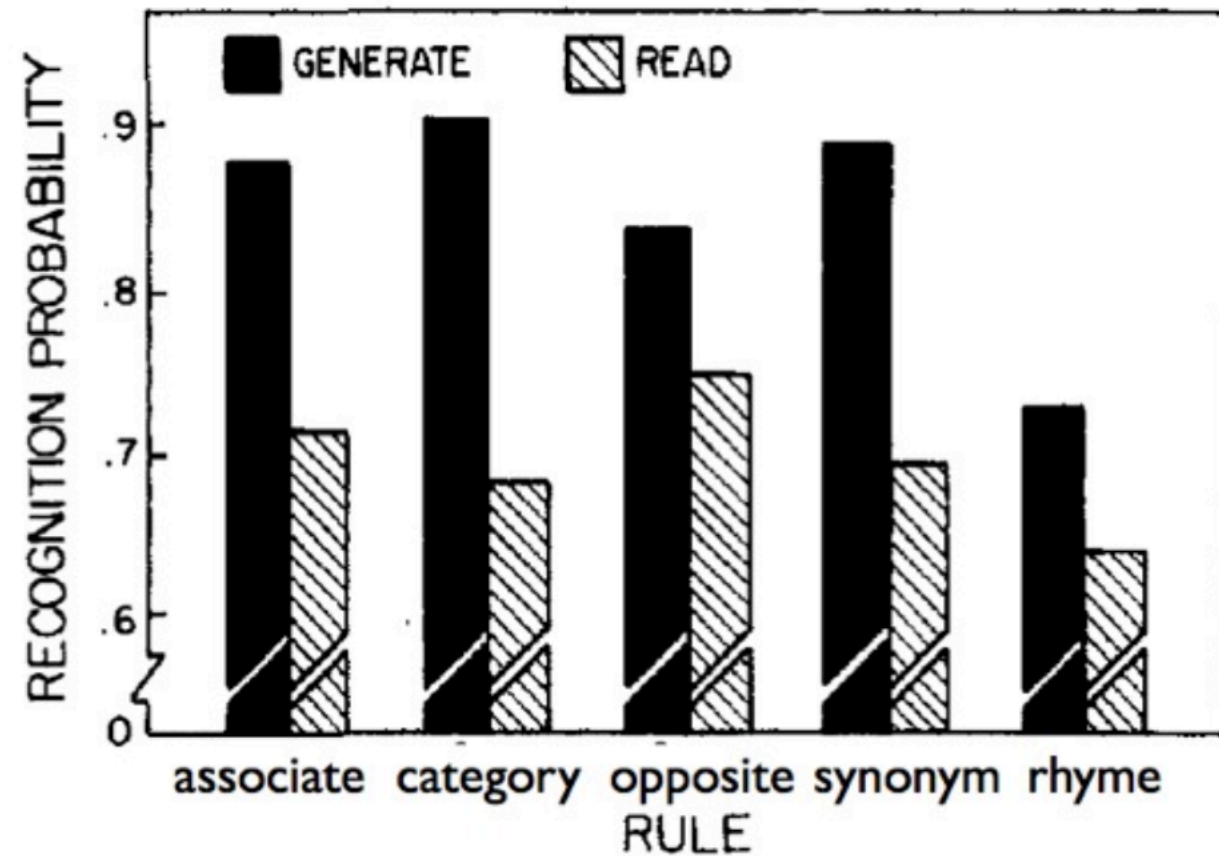
king - _____

horse-_____

lamp-_____

Testing (and generation) effect

- Better able to recognize words they had generated than words they read



Testing (and generation) effect

- Retrieving information from memory results in stronger memories than repeated study opportunities
- e.g., preparing for a test by answering practice questions is more effective than re-reading or re-writing notes

Learning is typically identified with encoding or construction of knowledge, and retrieval is considered merely the assessment of learning that occurred in a prior experience. - Karpicke (2012)

Testing (and generation) effect

Karpicke & Roediger (2008)

- Compared whether studying or testing is better for memory
- Study Swahili-English word pairs (*mashua* - *boat*)
- After studying, given test (*mashua* - ?)
- Repeat the study and test sections but varied which words were included in study and test

Testing (and generation) effect

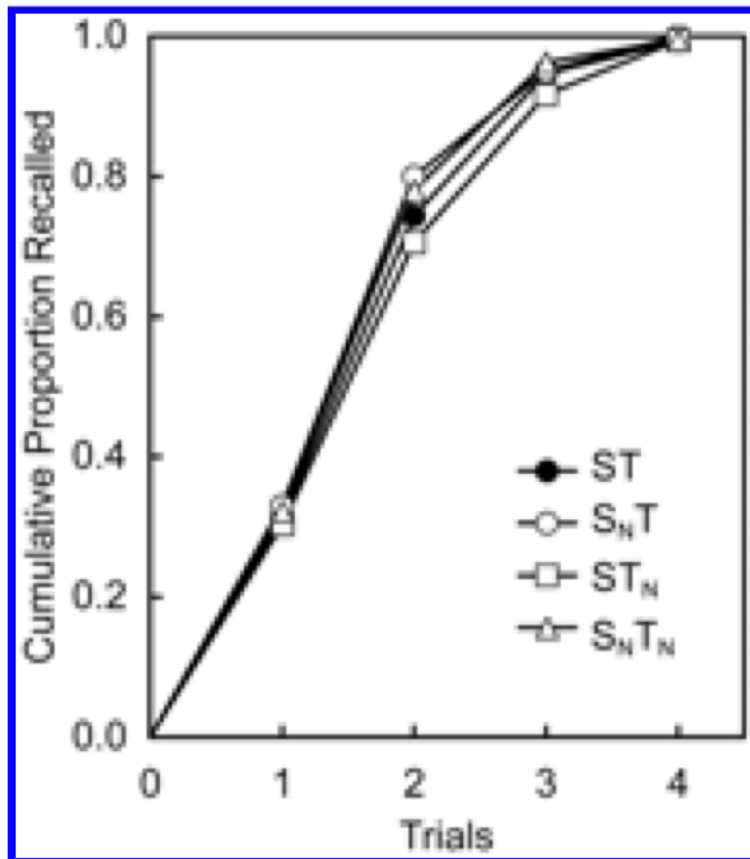
Karpicke & Roediger (2008)

- Conditions
 - **ST:** all word pairs were studied and testing in all sections until you got them all right
 - **SnT:** once you got a word correct in a test, it was dropped from later *study* blocks but was kept in later *test* blocks
 - **STn:** once you got a word correct in a test, it was dropped from later test blocks but kept in later study blocks
 - **SnTn:** once you got a word correct in a test, it was dropped from all later blocks.

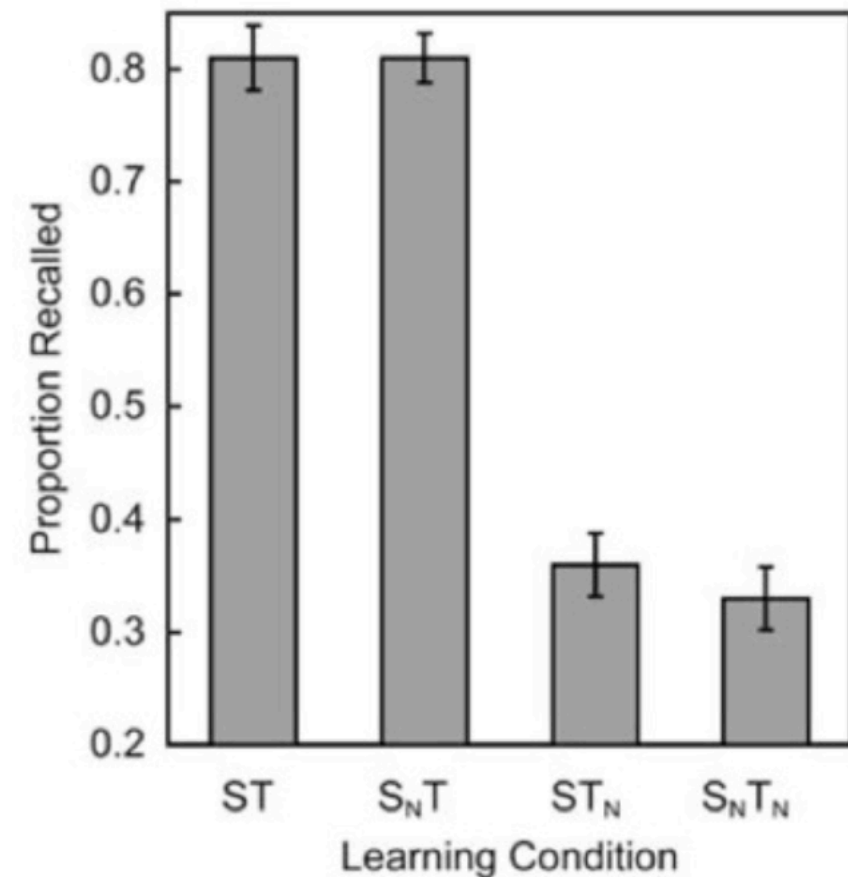
Jeffrey D. Karpicke Henry L. Roediger, The Critical Importance of Retrieval for Learning. *Science*, 319,966-968(2008). DOI:[10.1126/science.1152408](https://doi.org/10.1126/science.1152408)

Testing (and generation) effect

Karpicke & Roediger (2008)



Learned
Equally well.
One week
Later....



Jeffrey D. Karpicke Henry L. Roediger, The Critical Importance of Retrieval for Learning. *Science*, 319,966-968(2008). DOI:[10.1126/science.1152408](https://doi.org/10.1126/science.1152408)

Testing (and generation) effect

Roediger & Karpicke (2006)

- Students read educational text and recalled under three conditions
 - **SSSS**: repeated study over four sessions
 - **SSSR**: three study period one retrieval period
 - **SRRR**: one study three retrievals

Roediger, H. L., & Karpicke, J. D. (2006). Test-Enhanced Learning: Taking Memory Tests Improves Long-Term Retention. *Psychological Science*, 17(3), 249–255. <https://doi.org/10.1111/j.1467-9280.2006.01693.x>

Testing (and generation) effect

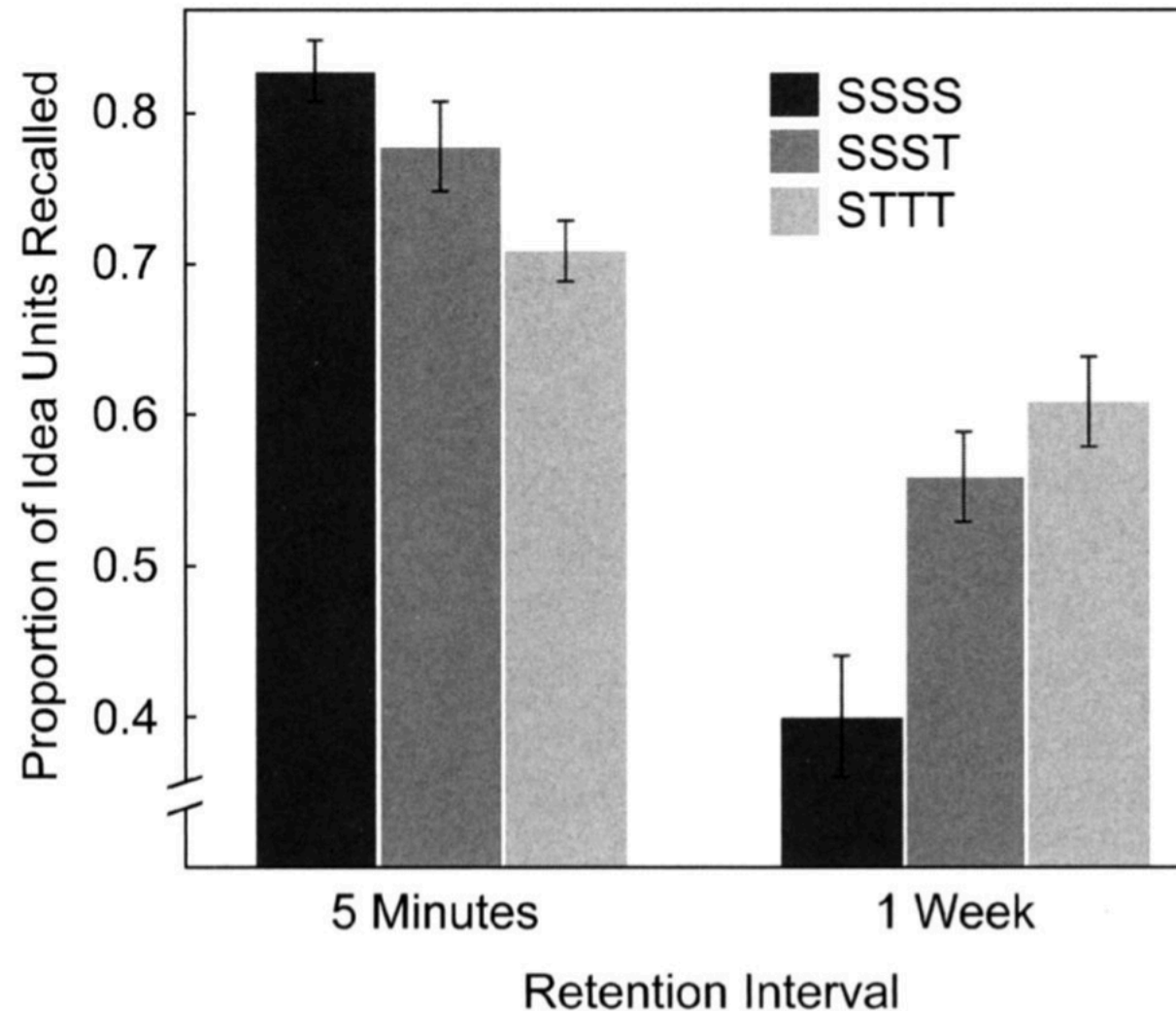


Fig. 2. Mean proportion of idea units recalled on the final test after a 5-min or 1-week retention interval as a function of learning condition (SSSS, SSST, or STTT) in Experiment 2. The labels for the learning conditions indicate the order of study (S) and test (T) periods. Error bars represent standard errors of the means.

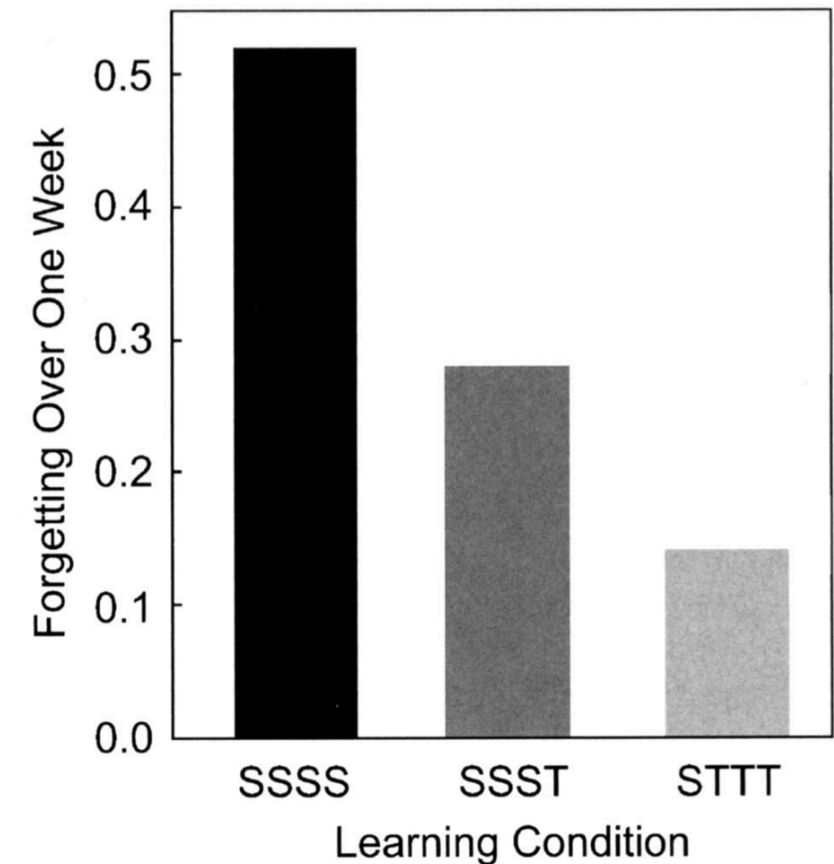


Fig. 3. Forgetting over 1 week as a function of learning condition (SSSS, SSST, or STTT) in Experiment 2. The labels for the learning conditions indicate the order of study (S) and test (T) periods.

(Initial recall-final recall)/initial recall

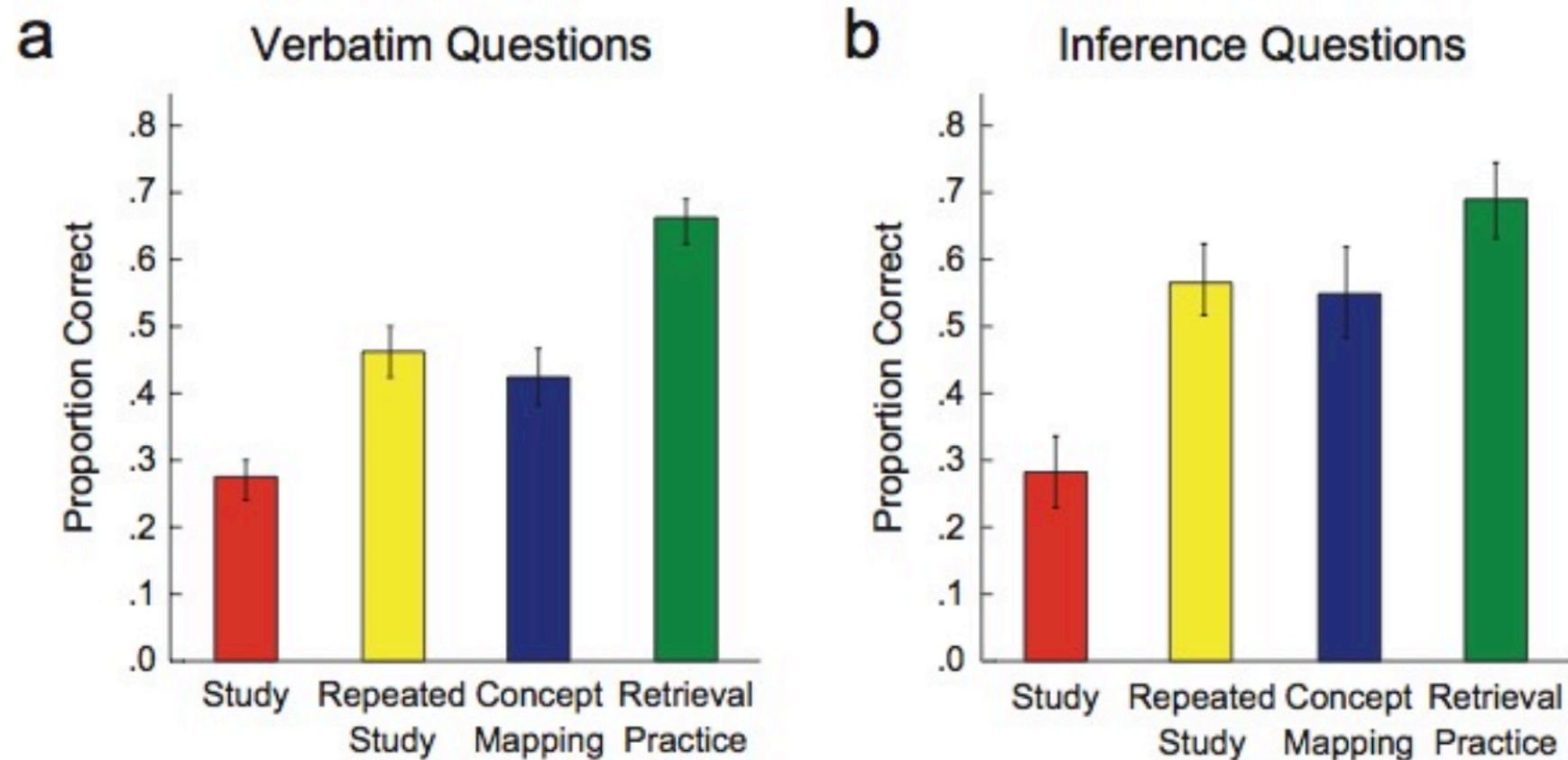
Testing (and generation) effect

Karpicke & Blunt (2011)

- Measured whether testing would benefit the learning of scientific concepts
- Included several comparison conditions that differed in the depth of processing.
- **Concept mapping:** an elaborative study method where you organize material and encode relationships among concepts.

Testing (and generation) effect

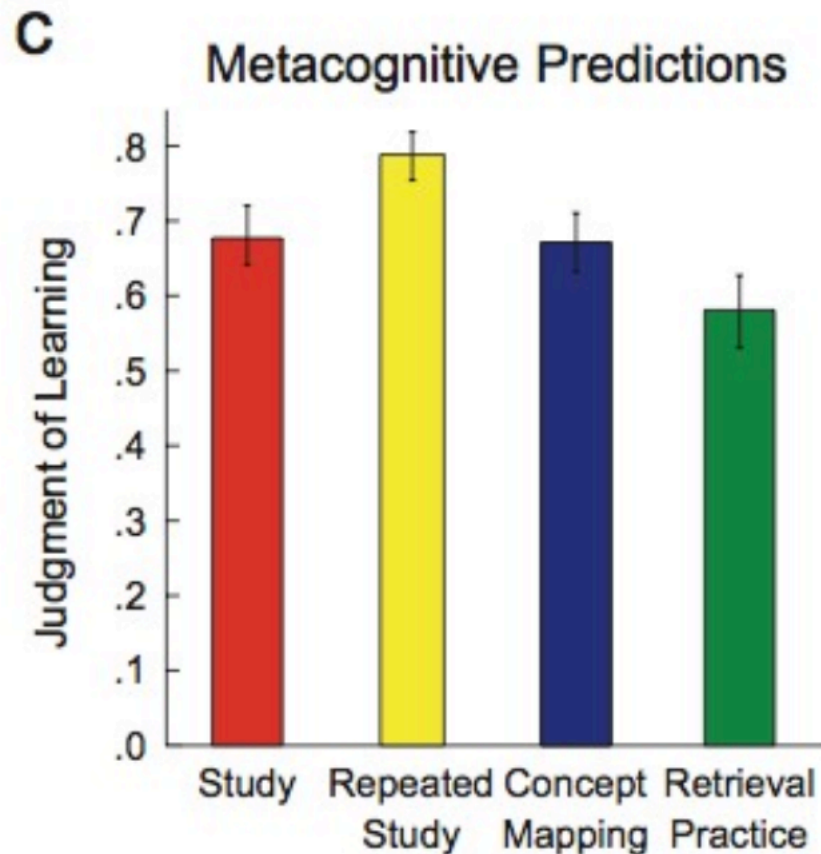
Karpicke & Blunt (2011)



Jeffrey D. Karpicke Janell R. Blunt, Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping. *Science* 331, 772-775 (2011). DOI: [10.1126/science.1199327](https://doi.org/10.1126/science.1199327)

Testing (and generation) effect

Karpicke & Blunt (2011)



Once again, people were bad at predicting what would help them learn!!

Take home message

- Two very important things you can do to improve memory: space and test!
- In every case people's *intuitions* about how your memory works is different than what really works to improve your memory.
- Next time you say "I learn better like this" catch yourself... is that really true or is that just your feeling?