

How Testing Can Benefit Past And Future Learning.

Rebecca Crowley
09/07/21



ROYAL
HOLLOWAY
UNIVERSITY
OF LONDON

Outline.



- What is the testing effect?
- Testing benefits past learning.
- Testing benefits future learning.

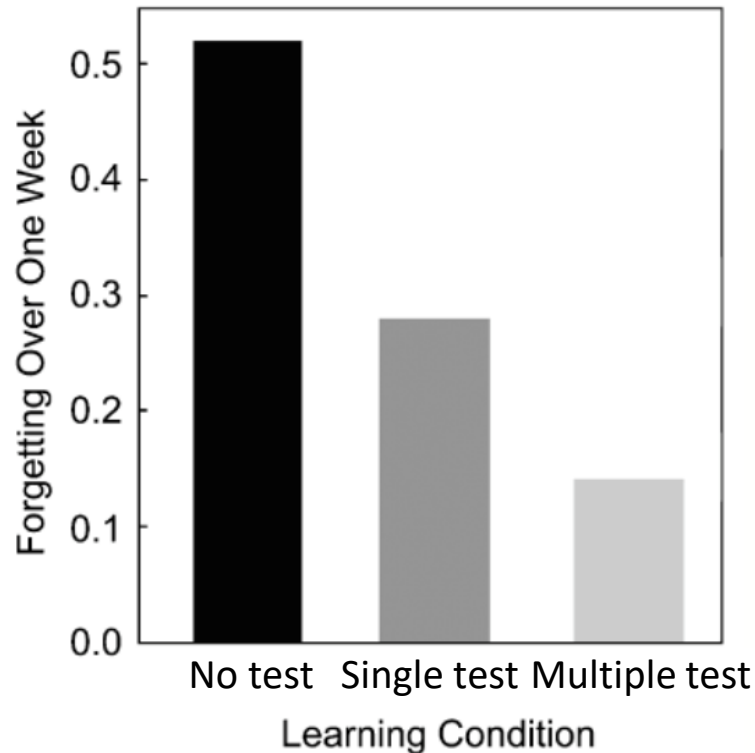
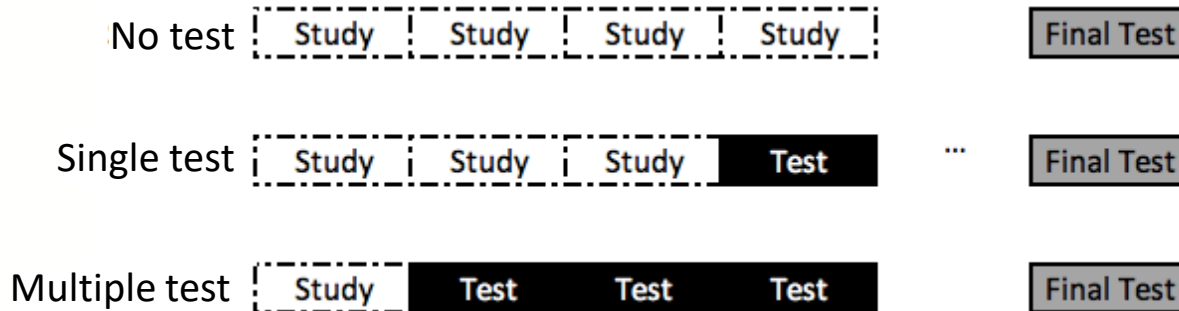
What Is The **Testing Effect**?



Testing effect = learning and memory performance is better when learning involves **repeated testing** compared to additional studying.

“Repeated retrieval during learning is the key to long-term retention” (Karpicke & Roediger, 2007, pg 151).

What Is The Testing Effect?



What Is The **Testing Effect**?



The testing effect is **robust**:

- Replicates in classroom-based settings
- Nonsense syllables, word lists, prose, foreign vocabulary, paired associates, spatial layouts
- Free recall, cued recall, recognition/multiple-choice testing, short answer testing
- More difficult retrieval protocols elicit bigger benefits
- Greater proportion of test to restudy trials
- Elaborative feedback is beneficial.

Outline.



- What is the testing effect?
- Testing benefits past learning.
- Testing benefits future learning.

Testing benefits **past learning**.



Learn information -> Test yourself -> Check -> Repeat = Better memory for that **specific** information.

Backward testing effect has had a **big impact** on teaching practise:

- Flashcards
- Weekly quizzes
- Past papers
- Mock exams

<https://www.early-career-framework.education.gov.uk/edt/edt-early-career-framework/self-directed-study-materials/8-how-pupils-learn-making-it-stick/8-2-understanding-the-evidence/>

<https://researchschool.org.uk/news/effective-retrieval-practice-what-should-we-consider>

<https://educationendowmentfoundation.org.uk/news/does-research-on-retrieval-practice-translate-into-classroom-practice/>

Outline.

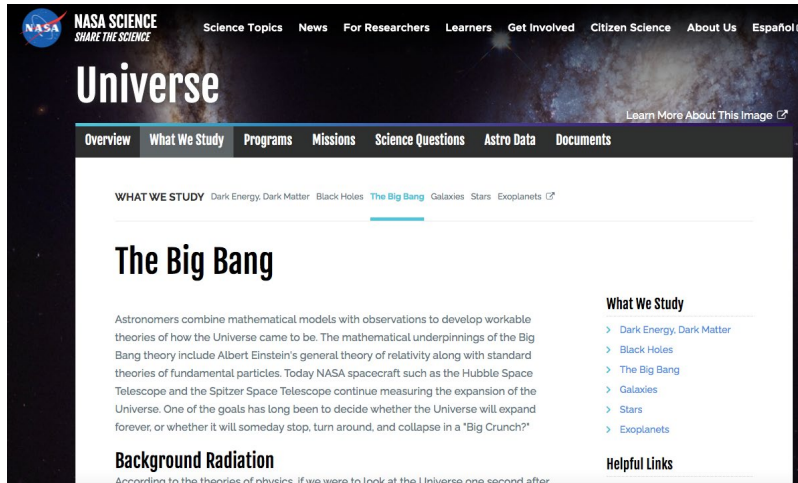


- What is the testing effect?
- Testing benefits past learning.
- Testing benefits future learning.

Testing benefits **future learning**.



- Testing benefits memory for **related but non-tested information**.



CONTENTS

1. [Where Is Angkor Wat?](#)
2. [Angkor Wat's Design](#)
3. [Angkor Wat Today](#)
4. [Sources](#)

Angkor Wat is an enormous Buddhist temple complex located in northern Cambodia. It was originally built in the first half of the 12th century as a Hindu temple. Spread across more than 400 acres, Angkor Wat is said to be the largest religious monument in the world. Its name, which translates to "temple city" in the Khmer language of the region, references the fact it was built by Emperor Suryavarman II, who ruled the region from 1113 to 1150, as the state temple and political center of his empire.

Half article = tested

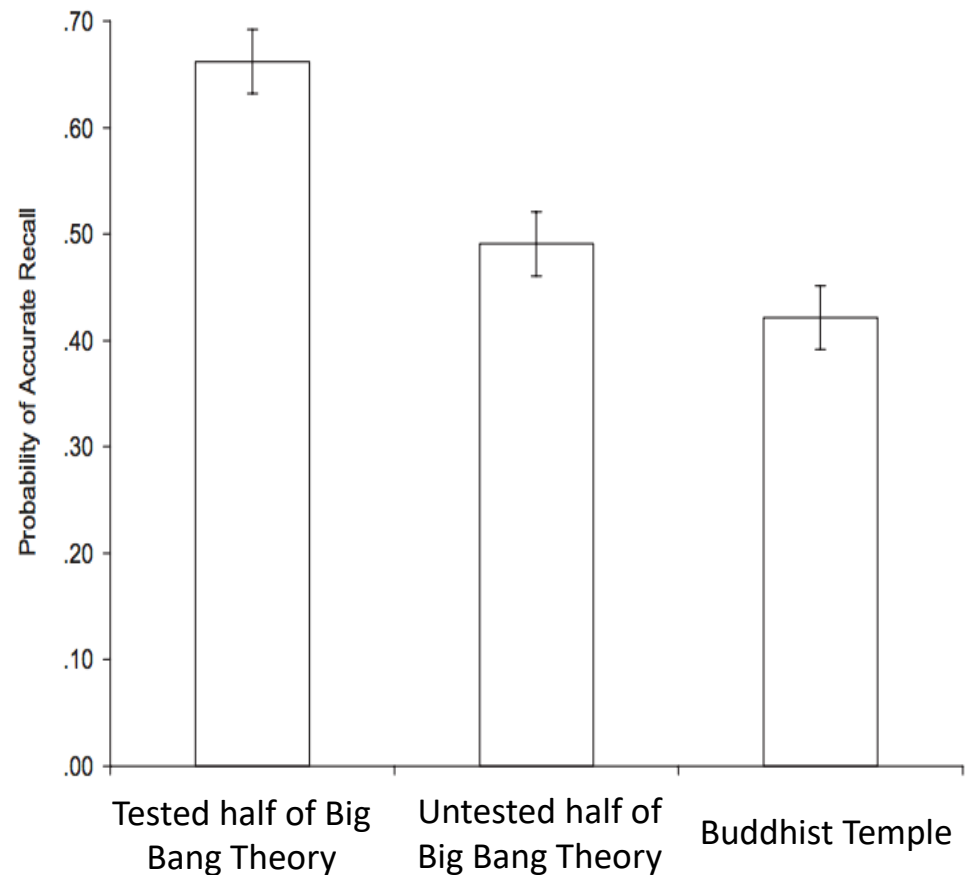
Other half = untested

All article = study only

Testing benefits **future learning**.



- Testing benefits memory for **related but non-tested information**.
- Implications for revision: **breadth of questions is better** than depth

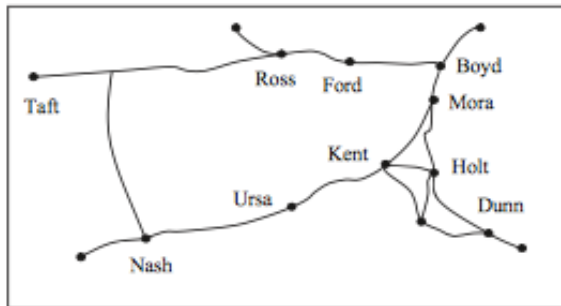


Testing benefits **future learning**.

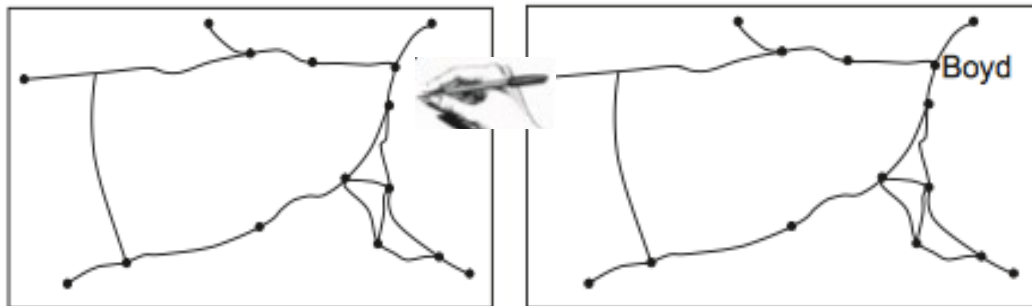


- Testing benefits our ability to use knowledge flexibly to **answer new questions**.

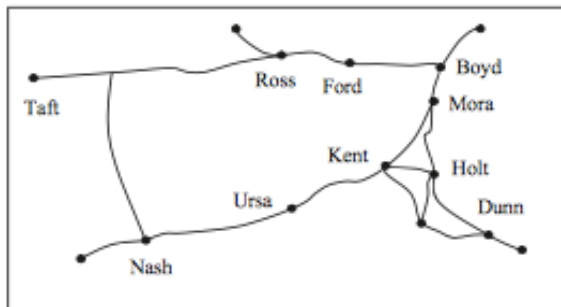
Test Group



Boyd



Study Group

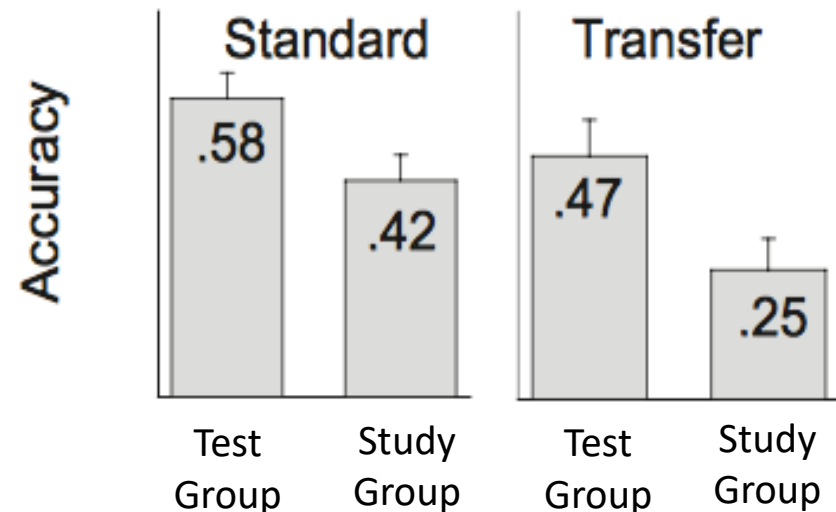


Testing benefits **future learning**.



Two types of questions at final test: standard and transfer

- **Standard** = “Write down where Boyd is on the map.”
- **Transfer** = “If you were travelling from Boyd to Nash, which places would you travel through?”
- Testing benefits our ability to use knowledge flexibly to **answer new questions**.
- **Implications for exams** where students apply knowledge to new questions.



Testing benefits **future learning**.



- Testing helps us to uncover **general principles or rules**.



Lucas Cranach the Elder



Sandro Botticelli



Jan van Eyck

Groups

Interim Test

Study

Math

Test

Interim Math

Study

Math

Math

Interim Study

Study

Math

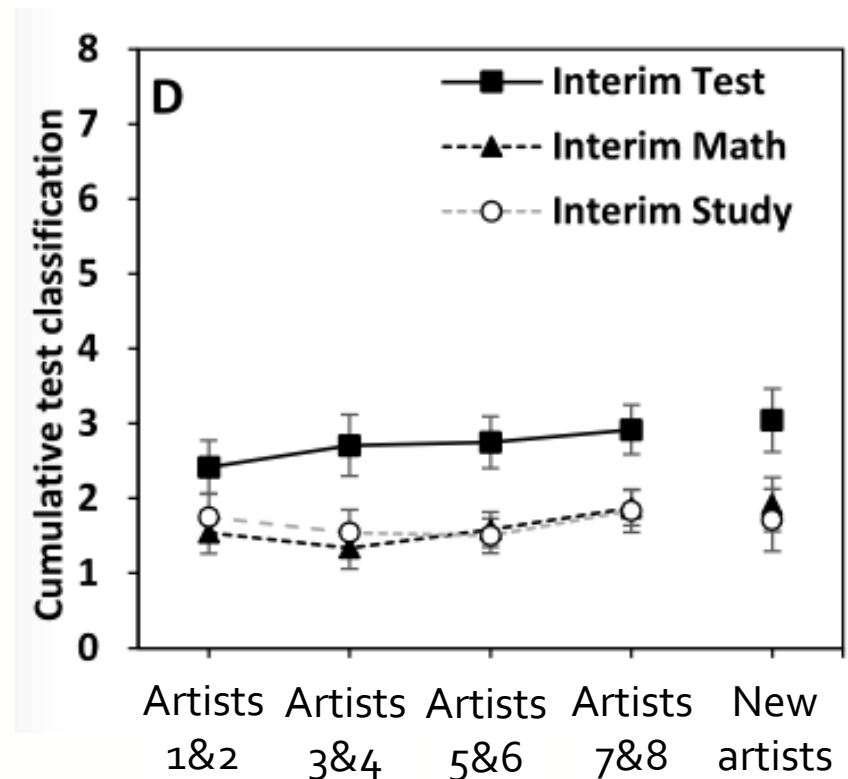
Study

Cumulative Test

Testing benefits **future learning**.



- Testing helps us to uncover **general principles or rules**.
- Useful for **deeper learning and organising information**.
- Testing helps participants to **infer an artistic style** without ever having been explicitly taught these rules.



Take Home.



Flashcards, weekly quizzes, past papers, and mock exams help us to:

- Strengthen our memory for information that was **tested directly**
- Strengthen our memory for information that is **related but was not tested** directly
- **Apply** our knowledge flexibly to answer questions that differ to those experienced during learning
- **Infer** rules, principles, and categories that govern information

These findings have **implications** for:

- Efficient **revision**
- **Exam** performance
- **Deeper and structured** learning

Thank you!



ROYAL
HOLLOWAY
UNIVERSITY
OF LONDON

References.



- Amato, M. S., & MacDonald, M. C. (2010). Sentence processing in an artificial language: Learning and using combinatorial constraints. *Cognition*, *116*(1), 143-148. doi: [10.1016/j.cognition.2010.04.001](https://doi.org/10.1016/j.cognition.2010.04.001).
- Antony, J. W., Ferreira, C. S., Norman, K. A., & Wimber, M. (2017). Retrieval as a fast route to memory consolidation. *Trends in Cognitive Sciences*, *21*(8), 573-576. doi: [10.1016/j.tics.2017.05.001](https://doi.org/10.1016/j.tics.2017.05.001).
- Baese-Berk, M. M., & Samuel, A. G. (2016). Listeners beware: Speech production may be bad for learning speech sounds. *Journal of Memory and Language*, *89*, 23-36. doi: [10.1016/j.jml.2015.10.008](https://doi.org/10.1016/j.jml.2015.10.008).
- Bixby, C. (2016). Using the Power of Language to Foster Community. In *English Teaching Forum* (Vol. 54, No. 2, pp. 33-36). Washington, DC: US Department of State. Bureau of Educational and Cultural Affairs, Office of English Language Programs.
- Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. *Cognition*, *104*(3), 437-458. doi: [10.1016/j.cognition.2006.07.003](https://doi.org/10.1016/j.cognition.2006.07.003).
- Born, J., & Wilhelm, I. (2012). System consolidation of memory during sleep. *Psychological Research*, *76*(2), 192-203. doi: [10.1007/s00426-011-0335-6](https://doi.org/10.1007/s00426-011-0335-6).
- Branigan, H. P., McLean, J. F., & Jones, M. (2005). A blue cat or a cat that is blue? Evidence for abstract syntax in young children's noun phrases. In *Proceedings of the 29th Annual Boston University Conference on Language Development* (pp. 109-121). Somerville, MA: Cascadilla Press.
- Butler, A. C. (2010). Repeated testing produces superior transfer of learning relative to repeated studying. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(5), 1118-1133. doi: [10.1037/a0019902](https://doi.org/10.1037/a0019902).
- Butler, A. C., Black-Maier, A. C., Raley, N. D., & Marsh, E. J. (2017). Retrieving and applying knowledge to different examples promotes transfer of learning. *Journal of Experimental Psychology: Applied*, *23*(4), 433-446. doi: [10.1037/xap0000142](https://doi.org/10.1037/xap0000142).
- Callender, A. A., & McDaniel, M. A. (2009). The limited benefits of rereading educational texts. *Contemporary Educational Psychology*, *34*(1), 30-41. doi: [10.1016/j.cedpsych.2008.07.001](https://doi.org/10.1016/j.cedpsych.2008.07.001).

References.



Carpenter, S. K. (2012). Testing enhances the transfer of learning. *Current Directions in Psychological Science*, 21(5), 279-283. doi: [10.1177/0963721412452728](https://doi.org/10.1177/0963721412452728).

Carpenter, S. K., & Kelly, J. W. (2012). Tests enhance retention and transfer of spatial learning. *Psychonomic Bulletin & Review*, 19(3), 443-448. doi: [10.3758/s13423-012-0221-2](https://doi.org/10.3758/s13423-012-0221-2).

Carpenter, S. K., & Pashler, H. (2007). Testing beyond words: Using tests to enhance visuospatial map learning. *Psychonomic Bulletin & Review*, 14(3), 474-478. doi: [10.3758/BF03194092](https://doi.org/10.3758/BF03194092).

Carpenter, S. K., Pashler, H., Wixted, J. T., & Vul, E. (2008). The effects of tests on learning and forgetting. *Memory & Cognition*, 36(2), 438-448. doi: [10.3758/MC.36.2.438](https://doi.org/10.3758/MC.36.2.438).

Chan, J. C. (2009). When does retrieval induce forgetting and when does it induce facilitation? Implications for retrieval inhibition, testing effect, and text processing. *Journal of Memory and Language*, 61(2), 153-170. doi: [10.1016/j.jml.2009.04.004](https://doi.org/10.1016/j.jml.2009.04.004).

Chan, J. C., McDermott, K. B., & Roediger III, H. L. (2006). Retrieval-induced facilitation: Initially nontested material can benefit from prior testing of related material. *Journal of Experimental Psychology: General*, 135(4), 553-571. doi: [10.1037/0096-3445.135.4.553](https://doi.org/10.1037/0096-3445.135.4.553).

Cranney, J., Ahn, M., McKinnon, R., Morris, S., & Watts, K. (2009). The testing effect, collaborative learning, and retrieval-induced facilitation in a classroom setting. *European Journal of Cognitive Psychology*, 21(6), 919-940. doi: [10.1080/09541440802413505](https://doi.org/10.1080/09541440802413505).

Ferreira, C. S., Charest, I., & Wimber, M. (2019). Retrieval aids the creation of a generalised memory trace and strengthens episode-unique information. *NeuroImage*, 201, 115996. doi: [10.1016/j.neuroimage.2019.07.009](https://doi.org/10.1016/j.neuroimage.2019.07.009).

Himmer, L., Schönauer, M., Heib, D. P. J., Schabus, M., & Gais, S. (2019). Rehearsal initiates systems memory consolidation, sleep makes it last. *Science Advances*, 5(4), eaav1695. doi: [10.1126/sciadv.aav1695](https://doi.org/10.1126/sciadv.aav1695).

Hinze, S. R., Wiley, J., & Pellegrino, J. W. (2013). The importance of constructive comprehension processes in learning from tests. *Journal of Memory and Language*, 69(2), 151-164. doi: [10.1016/j.jml.2013.03.002](https://doi.org/10.1016/j.jml.2013.03.002).

References.



Hopman, E. W., & MacDonald, M. C. (2018). Production practice during language learning improves comprehension. *Psychological Science*, 29(6), 961-971. doi: [10.1177/0956797618754486](https://doi.org/10.1177/0956797618754486).

Jacoby, L. L., Wahlheim, C. N., & Coane, J. H. (2010). Test-enhanced learning of natural concepts: Effects on recognition memory, classification, and metacognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 36(6), 1441-1451. doi: [10.1037/a0020636](https://doi.org/10.1037/a0020636).

Kang, S. H., McDaniel, M. A., & Pashler, H. (2011). Effects of testing on learning of functions. *Psychonomic Bulletin & Review*, 18(5), 998-1005. doi: [10.3758/s13423-011-0113-x](https://doi.org/10.3758/s13423-011-0113-x).

Karpicke, J. D., & Roediger III, H. L. (2007). Repeated retrieval during learning is the key to long-term retention. *Journal of Memory and Language*, 57(2), 151-162. doi: [10.1016/j.jml.2006.09.004](https://doi.org/10.1016/j.jml.2006.09.004).

Karpicke, J. D., & Roediger, H. L. (2008). The critical importance of retrieval for learning. *Science*, 319(5865), 966-968. doi: [10.1126/science.1152408](https://doi.org/10.1126/science.1152408).

Krashen, S. D. (2003). *Explorations in language acquisition and use*. Portsmouth, NH: Heinemann.

Latimier, A., Riegert, A., Peyre, H., Ly, S. T., Casati, R., & Ramus, F. (2019). Does pre-testing promote better retention than post-testing?. *NPJ Science of Learning*, 4(1), 1-7. doi: [10.1038/s41539-019-0053-1](https://doi.org/10.1038/s41539-019-0053-1).

Marshall, L., & Born, J. (2007). The contribution of sleep to hippocampus-dependent memory consolidation. *Trends in Cognitive Sciences*, 11(10), 442-450. doi: [10.1016/j.tics.2007.09.001](https://doi.org/10.1016/j.tics.2007.09.001).

McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, 102(3), 419-457. doi: [10.1037/0033-295X.102.3.419](https://doi.org/10.1037/0033-295X.102.3.419).

McDaniel, M. A., Wildman, K. M., & Anderson, J. L. (2012). Using quizzes to enhance summative-assessment performance in a web-based class: An experimental study. *Journal of Applied Research in Memory and Cognition*, 1(1), 18-26. doi: [10.1016/j.jarmac.2011.10.001](https://doi.org/10.1016/j.jarmac.2011.10.001).

References.



- Montag, J. L., & MacDonald, M. C. (2015). Text exposure predicts spoken production of complex sentences in 8-and 12-year-old children and adults. *Journal of Experimental Psychology: General*, *144*(2), 447-468. doi: [10.1037/xge0000054](https://doi.org/10.1037/xge0000054).
- Rickard, T. C., & Pan, S. C. (2018). A dual memory theory of the testing effect. *Psychonomic Bulletin & Review*, *25*(3), 847-869. doi: [10.3758/s13423-017-1298-4](https://doi.org/10.3758/s13423-017-1298-4).
- Roediger III, H. L., & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, *15*(1), 20-27. doi: [10.1016/j.tics.2010.09.003](https://doi.org/10.1016/j.tics.2010.09.003).
- Roediger III, H. L., & Karpicke, J. D. (2006a). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, *17*(3), 249-255. doi: [10.1111/j.1467-9280.2006.01693.x](https://doi.org/10.1111/j.1467-9280.2006.01693.x).
- Roediger III, H. L., & Karpicke, J. D. (2006b). The power of testing memory: Basic research and implications for educational practice. *Perspectives on Psychological Science*, *1*(3), 181-210. doi: [10.1111/j.1745-6916.2006.00012.x](https://doi.org/10.1111/j.1745-6916.2006.00012.x).
- Rohrer, D., Taylor, K., & Sholar, B. (2010). Tests enhance the transfer of learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(1), 233-239. doi: [10.1037/a0017678](https://doi.org/10.1037/a0017678).
- Rowland, C. A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin*, *140*(6), 1432-1463. doi: [10.1037/a0037559](https://doi.org/10.1037/a0037559).
- Segaert, K., Menenti, L., Weber, K., Petersson, K. M., & Hagoort, P. (2012). Shared syntax in language production and language comprehension—an fMRI study. *Cerebral Cortex*, *22*(7), 1662-1670. doi: [10.1093/cercor/bhr249](https://doi.org/10.1093/cercor/bhr249).
- Tamminen, J., Davis, M. H., Merkx, M., & Rastle, K. (2012). The role of memory consolidation in generalisation of new linguistic information. *Cognition*, *125*(1), 107-112. doi: [10.1016/j.cognition.2012.06.014](https://doi.org/10.1016/j.cognition.2012.06.014).
- Tran, R., Rohrer, D., & Pashler, H. (2015). Retrieval practice: The lack of transfer to deductive inferences. *Psychonomic Bulletin & Review*, *22*(1), 135-140. doi: [10.3758/s13423-014-0646-x](https://doi.org/10.3758/s13423-014-0646-x).

References.



Tulving, E. (1967). The effects of presentation and recall of material in free-recall learning. *Journal of Verbal Learning and Verbal Behavior*, 6(2), 175-184. doi: [10.1016/S0022-5371\(67\)80092-6](https://doi.org/10.1016/S0022-5371(67)80092-6).

Van den Broek, G., Takashima, A., Wiklund-Hörnqvist, C., Wirebring, L. K., Segers, E., Verhoeven, L., & Nyberg, L. (2016). Neurocognitive mechanisms of the "testing effect": A review. *Trends in Neuroscience and Education*, 5(2), 52-66. doi: [10.1016/j.tine.2016.05.001](https://doi.org/10.1016/j.tine.2016.05.001).

van Eersel, G. G., Verkoeijen, P. P., Povilenaite, M., & Rikers, R. (2016). The testing effect and far transfer: The role of exposure to key information. *Frontiers in Psychology*, 7, 1977. doi: [10.3389/fpsyg.2016.01977](https://doi.org/10.3389/fpsyg.2016.01977).

VanPatten, B., Collopy, E., Price, J. E., Borst, S., & Qualin, A. (2013). Explicit information, grammatical sensitivity, and the first-noun principle: A cross-linguistic study in processing instruction. *The Modern Language Journal*, 97(2), 506-527. doi: [10.1111/j.1540-4781.2013.12007.x](https://doi.org/10.1111/j.1540-4781.2013.12007.x).

Wooldridge, C. L., Bugg, J. M., McDaniel, M. A., & Liu, Y. (2014). The testing effect with authentic educational materials: A cautionary note. *Journal of Applied Research in Memory and Cognition*, 3(3), 214-221. doi: [10.1016/j.jarmac.2014.07.001](https://doi.org/10.1016/j.jarmac.2014.07.001).

Yang, C., & Shanks, D. R. (2018). The forward testing effect: Interim testing enhances inductive learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 44(3), 485-492. doi: [10.1037/xlm0000449](https://doi.org/10.1037/xlm0000449).