The Myth of Massed Practice

Most of us believe that learning is better when you go at something with single-minded purpose: the practice-practice-practice that's supposed to burn a skill into memory. Faith in focused, repetitive practice of one thing at a time until we've got it nailed is pervasive among classroom teachers, athletes, corporate trainers, and students. Researchers call this kind of practice "massed," and our faith rests in large part on the simple fact that when we do it, we can see it making a difference. Nevertheless, despite what our eyes tell us, this faith is misplaced.

If learning can be defined as picking up new knowledge or skills and being able to apply them later, then how *quickly* you pick something up is only part of the story. Is it *still there* when you need to use it out in the everyday world? While practicing is vital to learning and memory, studies have shown that practice is far more effective when it's broken into separate periods of training that are spaced out. The rapid gains produced by massed practice are often evident, but the rapid forgetting that follows is not. Practice that's spaced out, interleaved with other learning, and varied produces better mastery, longer retention, and more versatility. But these benefits come at a price: when practice is spaced, interleaved, and varied, it requires more effort. You feel the increased effort, but not the benefits the effort produces. Learning feels slower from this kind of practice, and you don't get the rapid improvements and affirmations you're accustomed to seeing from massed practice. Even in studies where the participants have shown superior results from spaced learning, they don't perceive the improvement; they *believe* they learned better on the material where practice was massed.

Almost everywhere you look, you find examples of massed practice: summer language boot camps, colleges that offer concentration in a single subject with the promise of fast learning, continuing education seminars for professionals where training is condensed into a single weekend. Cramming for exams is a form of massed practice. It feels like a productive strategy, and it may get you through the next day's midterm, but most of the material will be long forgotten by the time you sit down for the final. Spacing out your practice feels less productive for the very reason that some forgetting has set in and you've got to work harder to recall the concepts. It doesn't feel like you're on top of it. What you don't sense in the moment is that this added effort is making the learning stronger.[2]

Spaced Practice

The benefits of spacing out practice sessions are long established, but for a vivid example consider this study of thirty-eight surgical residents. They took a series of four short lessons in microsurgery: how to reattach tiny vessels. Each lesson included some instruction followed by some practice. Half the docs completed all four lessons in a single day, which is the normal in-service schedule. The others completed the same four lessons but with a week's interval between them.[3]

In a test given a month after their last session, those whose lessons had been spaced a week apart outperformed their colleagues in all areas—elapsed time to complete a surgery, number of hand movements, and success at reattaching the severed, pulsating aortas of live rats. The difference in performance between the two groups was impressive. The residents who had taken all four sessions in a single day not only scored lower on all measures, but 16 percent of them damaged the

rats' vessels beyond repair and were unable to complete their surgeries.

Why is spaced practice more effective than massed practice? It appears that embedding new learning in long-term memory requires a process of consolidation, in which memory traces (the brain's representations of the new learning) are strengthened, given meaning, and connected to prior knowledge—a process that unfolds over hours and may take several days. Rapid-fire practice leans on short-term memory. Durable learning, however, requires time for mental rehearsal and the other processes of consolidation. Hence, spaced practice works better. The increased effort required to retrieve the learning after a little forgetting has the effect of retriggering consolidation, further strengthening memory. We explore some of the theories about this process in the next chapter.

Interleaved Practice

Interleaving the practice of two or more subjects or skills is also a more potent alternative to massed practice, and here's a quick example of that. Two groups of college students were taught how to find the volumes of four obscure geometric solids (wedge, spheroid, spherical cone, and half cone). One group then worked a set of practice problems that were clustered by problem type (practice four problems for computing the volume of a wedge, then four problems for a spheroid, etc.). The other group worked the same practice problems, but the sequence was mixed (interleaved) rather than clustered by type of problem. Given what we've already presented, the results may not surprise you. During practice, the students who worked the problems in clusters (that is, massed) averaged 89 percent correct, compared to only 60 percent for those who worked the problems in a mixed sequence. But in the

final test a week later, the students who had practiced solving problems clustered by type averaged only 20 percent correct, while the students whose practice was interleaved averaged 63 percent. The mixing of problem types, which boosted final test performance by a remarkable 215 percent, actually *impeded* performance during initial learning.[4]

Now, suppose you're a trainer in a company trying to teach employees a complicated new process that involves ten procedures. The typical way of doing this is to train up in procedure 1, repeating it many times until the trainees really seem to have it down cold. Then you go to procedure 2, you do many repetitions of 2, you get that down, and so on. That appears to produce fast learning. What would interleaved practice look like? You practice procedure 1 just a few times, then switch to procedure 4, then switch to 3, then to 7, and so on. (Chapter 8 tells how Farmers Insurance trains new agents in a spiraling series of exercises that cycle back to key skillsets in a seemingly random sequence that adds layers of context and meaning at each turn.)

The learning from interleaved practice feels slower than learning from massed practice. Teachers and students sense the difference. They can see that their grasp of each element is coming more slowly, and the compensating long-term advantage is not apparent to them. As a result, interleaving is unpopular and seldom used. Teachers dislike it because it feels sluggish. Students find it confusing: they're just starting to get a handle on new material and don't feel on top of it yet when they are forced to switch. But the research shows unequivocally that mastery and long-term retention are much better if you interleave practice than if you mass it.

Varied Practice

Okay, what about the beanbag study where the kids who did best had *never* practiced the three-foot toss that the other kids had *only* practiced?

The beanbag study focused on mastery of motor skills, but much evidence has shown that the underlying principle applies to cognitive learning as well. The basic idea is that *varied* practice—like tossing your beanbags into baskets at mixed distances—improves your ability to transfer learning from one situation and apply it successfully to another. You develop a broader understanding of the relationships between different conditions and the movements required to succeed in them; you discern context better and develop a more flexible "movement vocabulary"—different movements for different situations. Whether the scope of variable training (e.g., the two- and four-foot tosses) must encompass the particular task (the three-foot toss) is subject for further study.

The evidence favoring variable training has been supported by recent neuroimaging studies that suggest that different kinds of practice engage different parts of the brain. The learning of motor skills from varied practice, which is more cognitively challenging than massed practice, appears to be consolidated in an area of the brain associated with the more difficult process of learning higher-order motor skills. The learning of motor skills from massed practice, on the other hand, appears to be consolidated in a different area of the brain that is used for learning more cognitively simple and less challenging motor skills. The inference is that learning gained through the less challenging, massed form of practice is encoded in a simpler or comparatively impoverished representation than the learning gained from the varied and more challenging practice

which demands more brain power and encodes the learning in a more flexible representation that can be applied more broadly.[5]

Among athletes, massed practice has long been the rule: take your hook shot, knock the twenty-foot putt, work your backhand return, throw the pass while rolling out: again and again and again—to get it right and train your "muscle memory." Or so the notion holds. The benefits of variable training for motor learning have been gaining broader acceptance, albeit slowly. Consider the one-touch pass in hockey. That's where you receive the puck and immediately pass it to a teammate who's moving down the ice, keeping the opposition off balance and unable to put pressure on the puck carrier. Jamie Kompon, when he was assistant coach of the Los Angeles Kings, was in the habit of running team practice on one-touch passes from the same position on the rink. Even if this move is interleaved with a sequence of other moves in practice, if you only do it at the same place on the rink or in the same sequence of moves, you are only, as it were, throwing your beanbags into the three-foot bucket. Kompon is onto the difference now and has changed up his drills. Since we talked, he's gone over to the Chicago Blackhawks. We would have said "Keep an eye on those Blackhawks" here, but as we revise to go into production, Kompon and team have already won the Stanley Cup. Perhaps no coincidence?

The benefits of variable practice for cognitive as opposed to motor skills learning were shown in a recent experiment that adapted the beanbag test to verbal learning: in this case, the students solved anagrams–that is, they rearranged letters to form words (*tmoce* becomes *comet*). Some subjects practiced the same anagram over and over, whereas others practiced multiple anagrams for the word. When they were all tested on the same anagram that the former group had practiced on,

the latter group performed better on it! The same benefits will apply whether you are practicing to identify tree species, differentiate the principles of case law, or master a new computer program.[6]

Developing Discrimination Skills

Compared to massed practice, a significant advantage of interleaving and variation is that they help us learn better how to assess context and discriminate between problems, selecting and applying the correct solution from a range of possibilities. In math education, massing is embedded in the textbook: each chapter is dedicated to a particular kind of problem, which you study in class and then practice by working, say, twenty examples for homework before you move on. The next chapter has a different type of problem, and you dive into the same kind of concentrated learning and practice of that solution. On you march, chapter by chapter, through the semester. But then, on the final exam, lo and behold, the problems are all mixed up: you're staring at each one in turn, asking yourself *Which algorithm do I use?* Was it in chapter 5, 6, or 7? When you have learned under conditions of massed or blocked repetition, you have had no practice on that critical sorting process. But this is the way life usually unfolds: problems and opportunities come at us unpredictably, out of sequence. For our learning to have practical value, we must be adept at discerning "What kind of problem is this?" so we can select and apply an appropriate solution.

Several studies have demonstrated the improved powers of discrimination to be gained through interleaved and varied practice. One study involved learning to attribute paintings to the artists who created them, and another focused on learning to identify and classify birds.

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