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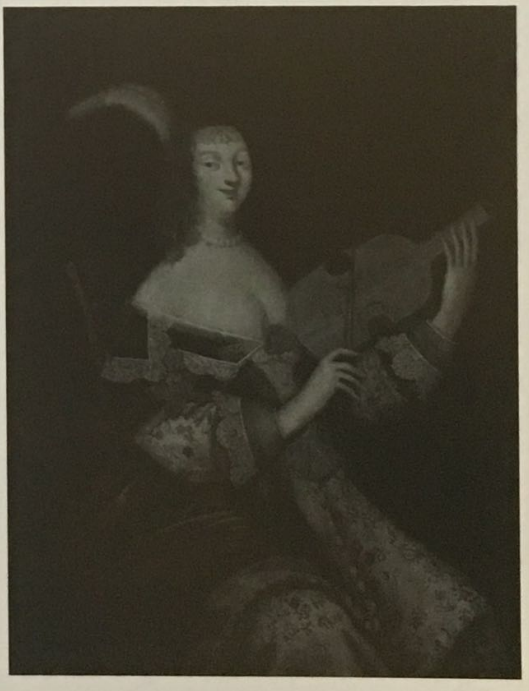

On the Cover:
English School, seventeenth-century
A Lady Playing a Viola da Braccio
Oil on Canvas

Provided courtesy of Doyle New York, whose representative gave the following information about the painting: "It comes to us from a private collector in New York City, who bought it from an antique dealer in the city some years ago. The painting is not titled in the sense that modern paintings are; our 'title' is simply a description of what is depicted."

Interleaved Practice: The Best Practice Method for Reliable Performance

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As performers, we are always looking for ways to enhance our consistency under pressure and to ensure that all of our hard work in the practice room doesn't disappear when we are on stage. We have all had the experience of performing below what we know we are capable of and wishing we could get a second chance. Although there are no magic bullets when it comes to becoming a better performer, there is one practice technique that science has shown to be far superior for enhanced performance: interleaved practicing.

The way most of us are taught to practice is called blocked (or massed) practice: we work on a particular piece for a large chunk of time before moving on to something new. Similarly, we were all taught to play a passage a certain number of times perfectly to solidify it in our hands. These practice methods are all well and good (and maybe necessary) for learning new pieces and solidifying skills, but they are not enough if we wish to perform well because they do not allow us to practice what our brains have to do when we perform. In a concert, we do not get to play a tricky passage several times before the one that actually counts. We get one chance to get it right and if we have never practiced playing something perfectly on the first try, our chances of executing it exactly how we want are not very good.

This is where interleaved practice (also known as random practice) comes in. A large number of studies have been done on the efficacy of interleaved practice in the realm of sports coaching. One of the clearest experiments looking at interleaved practicing is a study that was done on college baseball players.[1] In the study, the players were divided into two groups and each practiced hitting forty-five pitches. In the blocked practice group, they were pitched fifteen fastballs, fifteen curve balls, and fifteen change-up pitches and they had to hit as many as they could. The random practice group also got forty-five total pitches, but they never knew what was coming at them, so they might get a fastball, then three curveballs, then two change-up pitches, then five fastballs, etc. What the experimenters found was that during the practice session, the players in the blocked practice group hit more balls than those in the random practice group. However, when they tested their batting performance at a later date, those who had trained with blocked practice had gotten twenty-five percent better while those who had trained with random practice had gotten fifty-seven percent better, which is clearly a much bigger improvement.

These results are typical of nearly every single study that has been done on interleaved versus blocked practicing from basketball, to racquetball, badminton, golf, and snowboarding, to problem solving and studying in general, in the elderly, in children, and even in musicians.[2] All of these studies show fewer gains during the actual practice session for those doing interleaved practice, but enhanced ability in a performance situation as compared to those who used blocked practice. The fact that there are fewer apparent gains during practice make sense if you think about the baseball study: the players in the blocked practice group knew exactly what kind of pitch was coming, so they could prepare better to hit the ball accurately. On the other hand, those in the random practice group never knew what was coming next, meaning they had to adjust on the spot, resulting in a lower batting average.

This difficulty of adjusting on the spot is known in scientific circles as "contextual interference." To illustrate what this means more clearly, think about the technical aspects of performing a piece of music. This is obviously an oversimplification, but thinking of the cognitive framework for playing a particular passage being like that of a computer program (fingerings, bowings, shifts, dynamics, tone, phrasing, etc.), playing the same passage over and over just keeps rerunning the same program, whereas constant changes between programs is more taxing. Since the programs all draw on the same skills (albeit in different combinations for each piece), they interfere with one another (hence "contextual interference"). Looked at this way, it's no wonder gains aren't as apparent during an interleaved practice session. But interleaving is exactly what happens during a performance, so performers who have practiced in this way have an advantage when they get on stage; they have practiced not only what their hands and arms have to do, but also the cognitive shifts their brains will have to do.

The evidence that this also works for musicians comes from a study on pianists from 2013.[3] In the study, the pianists had to learn a group of short pieces that had been specifically composed for the experiment. The pieces were challenging enough that they weren't sight readable, but easy enough that they could be learned in a relatively short amount of time. All of the pianists learned all of the pieces, but some of the pieces were learned using blocked practice, while others were learned using interleaved practice in a practice schedule that was tightly controlled by the experimenters. Two days later, the pianists returned to the lab and performed a subset of the pieces for the researchers. Just like with the baseball players, the pianists performed the pieces they had learned using interleaved practice much better than the pieces they had learned using blocked practice (measured in terms of note and rhythm accuracy).

Musicians are just now learning about this research and method of practicing, but researchers have been studying interleaved practice for over 35 years. The very first study on random practicing, done in 1979, provides a critical detail in support of the idea that interleaved practicing is something all musicians should adopt if they want to perform their best. In this study, subjects had to learn different movement patterns to knock down wooden barriers.[4] Like in the baseball study, there was a blocked practice group and a random practice group. The critical detail comes in how performance was tested. Some of the subjects were tested in an interleaved fashion, while others were tested in a blocked fashion. This gave the experimenters four possible groups to look at: random practicing-random testing (RR), random practicing-blocked testing (RB), blocked practicing-blocked testing (BB), and blocked practicing-random testing (BR). What they found was that the subjects who performed the worst, by a very wide margin, were those who practiced using blocked practice, but who were tested in an interleaved manner. This is extremely important information for musicians because our performances are always a random retention test. If we are only doing blocked practice, this puts us at a severe disadvantage.[5]

Despite the overwhelming evidence that interleaved practice is superior to blocked practice, people persist in using blocked practice, even when they've seen that it is inferior. In fact, in the study on pianists mentioned earlier, they interviewed the pianists after the fact to see which practice method they thought was better. Even though the pianists could see for themselves that the pieces they had learned using interleaved practice were the ones they performed better, they still said they thought blocked practice was a better practice method. This is, in fact, so common that scientists have given it a name: the illusion of mastery. Blocked practice makes us feel like we have mastered the skill, but it is an illusion. It is a very powerful illusion, and is something we must

always guard against. Robert Bjork, one of the leading researchers on blocked practice, has the following to say: "Learners are prone to interpreting performance during acquisition as a valid index of learning, which can lead not only to misassessments of the degree to which learning has happened, but also to learners preferring poor conditions of learning over better conditions of learning."[6]

Understanding what is happening in the brain during interleaved practice instead of massed/blocked practice can help protect against this illusion. In a study from 2011, subjects had to learn to do six different four-finger sequences as quickly as possible.[7] Over the course of two days, the subjects in the study learned some of the sequences using blocked practice and some using random practice. On day five, they were tested on their performance in both a blocked and random retention test. During both the practice and the test, researchers were looking at what their brains were doing using functional MRI. The researchers found that during the practice session, the brains of the participants were much more highly activated in the random practice condition than in the blocked practice condition. This was especially true in areas of the brain involved in higher cognitive activities, such as movement planning, action selection, and working memory. In fact, there were no regions of the brain that were more activated during blocked practice over random practice. This explains why blocked practice may feel better to do: it's easier for the brain, so it makes us think we're doing a better job (that's the illusion of mastery). However, something different happened during performance. For the sequences the subjects learned using blocked practice, there was more activation during performance, which means the brain had to work harder to remember the sequences. Conversely, for the sequences the subjects learned using random practice, their brains were less activated during the test. Again, this was especially true for areas involved in higher cognitive activities, which the experimenters interpreted to mean that there was more efficient retrieval of the motor memory during the test as a result of the interleaved practicing. This explains why skills practiced using random practice end up being performed better: the brain doesn't have to work as hard during a performance if the materials have been learned using random practice. Our brains have enough to keep track of as it is when we are performing; we don't need to make it even harder by practicing using an inferior method.

One other recent study with intriguing results looked at the connections that form between different areas of the brain when someone is learning a new skill.[8] In this study, they found that one week after blocked practice, there was an increase in the connection between the prefrontal cortex and the anterior putamen. Previous studies have shown that the anterior putamen is involved in the early stages of motor learning when the skill is relatively poor. In contrast, one week of interleaved practice resulted in increased connection between the sensory motor cortex and the posterior putamen. This connection has been implicated in the long-term storage of skill, and previous studies have shown a shift from the anterior to the posterior putamen with increased training. The study here seems to imply that random practice essentially allows you to skip the early stages of learning, which is an intriguing finding. This is especially relevant when we are learning brand new skills (like extended techniques) or teaching beginning and intermediate level students.

Hopefully, all of the evidence presented thus far has convinced you that random practicing is worth trying. However, it would be a mistake to think that blocked practice has no place at all in the practice room. One final study illustrates the importance of doing both. This study was done with basketball players who were trying to increase their ability on three different types of passing.[9] In this study, there were three groups: a blocked practice group, a random practice group, and a group whose practice schedule was increasingly random. For this final group, they started with blocked practice, then they moved onto serial practice (that is, they worked on skill A, then skill B, then skill C, then skill A, then skill B, then skill C, etc.) This gradually increases the contextual interference while still being predictable. Finally, they ended with random practice. This study found that the group that was given the increasingly random practice schedule made the most improvement, much more so than the blocked practice group, but also even more than the strictly random practice group. It seems that blocked practice helps solidify the skill, gradually increasing the contextual interference through serial practice increases the level of difficulty, and finally random practice arrives at a practice schedule that mimics what the brain will have to do in an actual performance situation.
There are an infinite number of ways to use the principles of random practice. There are two important concepts to keep in mind: 1) Random practicing is effective

because it forces you to constantly change your frame of mind, which mimics what your brain has to do during performance. 2) When using random practice to work on making entire passages reliable, because of the difficulty of what we have to do as musicians, if the skill hasn't been solidified using blocked practice, you will never be able to do it using random practice. Said another way, in order to play something perfectly from scratch right off the bat, it is first necessary to be able to play it perfectly and reliably a number of times in a row. Here are a few suggestions for how to implement the concept of interleaving into your practice:

Serial practice

Pick four to seven trouble spots in a piece you are working on and put sticky notes in your part next to each spot. Make sure that all of these are spots that you can do well a certain number of times in a row before you try to do this method. Play the first spot once and if it's perfect, give yourself a tick mark on the sticky note. Then, play the second spot and again give yourself a tick mark if it's perfect. Continue through all your spots until you've reached the final one. Then, go back to spot number one and play it again. If it's perfect, give yourself another tick mark. If you make a mistake, erase the first tick mark. Continue going through your spots like this until all of the sticky notes have a minimum of five tick marks on them. Remember, if you make a mistake in any of your spots, you have to erase the tick marks you've already accumulated for that spot and start over again at zero.

Use an interval timer

An interval timer is an app that allows you to set an alarm to go off every X number of minutes (or seconds). The one I use is called "Interval Timer" and it's free for iPhone and Android. I start using this practice method when I'm two to three weeks away from a concert or audition. Pick a spot that you've already solidified, but want to make sure to nail perfectly every time (the opening of your concerto, a tricky passage in the middle, etc.) and set your interval timer to go off however often you want (I set mine to go every five minutes). Go about your normal practice routine (clicking things up using the metronome, practicing things in rhythms, whatever you normally do) and then every time the timer goes off, stop what you're doing and go play the spot you picked ahead of time. Only play it once, just like it's a concert. Then return to whatever you were practicing. Don't work on the spot you just played, no matter how bad it is. You can make notes for yourself of places in the passage that need more practice so you can work on it later, but if you work on it now, you're defeating the purpose of interleaved practice.

You will find that the first few times you do this, the passage you picked won't be very good. This can be discouraging, but it's an accurate indicator of how well you can play the passage on the spot and how well it's likely to go in a performance. The more times you do this, you will learn the kind of focus you need to play the passage exactly how you want, and also what still needs work. Soon, you will find that every time the timer goes off, the passage will be consistent and reliable. When it's time for the concert, you won't worry about how it will go; you will know exactly how it will go because you have practiced playing it on the spot many times at home. (This is also an incredibly effective practice method for preparing an orchestra audition. Every time interval timer goes off, play a different excerpt.)

Another way to use an interval timer is to set it to go off every X number of minutes and whenever it goes off, switch what you are practicing. Right now, for instance, I'm learning a new piece of chamber music. I have my interval timer go off every five minutes and every time it goes off, I move to a different movement. This forces me to be extremely efficient in my practicing because I only get five minutes before I have to move on. When I cycle back to the movement I started with, it's a good test to see whether the practicing I did earlier really stuck. This won't be the only practicing I do on the piece (some things take longer than five minutes to work out, of course), but is one of many tools I use.

Mix up your technique routine

Instead of going around the circle of fifths with your scales and arpeggios, try using random practice instead. Make little cards, each one labeled with a different key, and put them in a small baggie. Then, make other cards labeled with different tempos and put those in a different baggie. Finally, make cards with different bow strokes or bowings on them and put those in the third baggie. Each day, pick out a key, a tempo, and a bow stroke and that's what you have to do that day for your scale.

Mock performances and auditions

People preparing for orchestra auditions often know the importance of doing mock auditions, but often we don't

hear about the importance of doing mock recitals. When I am getting ready for a performance or an audition, at least two weeks before the date, at the end of the day when I'm tired and my brain isn't working well anymore, I will do a mock audition or play my entire recital program. I will only warm up the way I plan to before the actual event to mimic as closely as possible what I will feel like at the concert or audition. I do this at the end of the day when I'm tired because I know that my brain won't be working quite normally during the performance, so I don't want to make my mock audition at a time of day when my brain is focused optimally. This simulates a performance situation (minus the nerves) and forces me to play everything perfectly the first time around. I also record each of these mock auditions/recitals and then take notes on what I heard so I know where to focus in my practicing the next day.

I have found that many performers are skeptical of random practice because it flies in the face of everything they were taught about good practicing. If you have never tried it before, it can be very frustrating to do at first because, like all the studies show, gains are slower during this kind of practice than in blocked practice. But the benefits are clear the minute you get up to perform something you have perfected using interleaved practice. It is obviously possible to play extremely well only doing blocked practice, but the science is clear: random practice is unequivocally the best practice method for enhanced performance. Just because we have been doing something one way for generations doesn't mean we shouldn't be open to trying something new, especially when there is overwhelming evidence as to its efficacy.

Molly Gebrian currently teaches viola, music theory, and a course on music and the brain at the University of Wisconsin-Eau Claire. Her interest in neuroscience started at Oberlin College and Conservatory, where she was a double-degree student in viola and neuroscience. After getting her master's degree at the New England Conservatory, she completed her DMA at Rice University, where she also continued her education and research into music and the brain.