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The Gold Standard

WHAT IS MISSING from purposeful practice? What is required beyond simply focusing and pushing beyond one's comfort zone? Let's talk about it.

As we saw in chapter 1, purposeful practice as done by different people can have very different results. Steve Faloon reached the point where he could remember up to eighty-two digits, while Renée, working just as hard as Steve, was unable to get beyond twenty. The difference lay in the details of the types of practice that Steve and Renée used to improve their memory.

Since Steve first demonstrated that it is possible to memorize long strings of numbers, dozens of memory competitors have developed digit memories beyond what Steve achieved. According to the World Memory Sports Council, which oversees international memory competitions, there are now at least five people who have managed to remember 300 or more digits in a memory competition, and several dozen who have memorized at least 100 digits. As of November 2015 the world record in this event was held by Tsogbadrakh Saikhanbayar

of Mongolia, who recalled 432 digits at the 2015 Taiwan Open Adult Memory Competition. That's more than five times as many digits as Steve's record. As with the disparity between Renée and Steve, the key difference between Steve's performance and that of the new generation of memory whizzes lies in the details of their training.

This is part of a general pattern. In every area, some approaches to training are more effective than others. In this chapter we'll explore the most effective method of all: deliberate practice. It is the gold standard, the ideal to which anyone learning a skill should aspire.

A HIGHLY DEVELOPED FIELD

Some activities, such as playing music in pop music groups, solving crossword puzzles, and folk dancing, have no standard training approaches. Whatever methods there are seem slapdash and produce unpredictable results. Other activities, like classical music performance, mathematics, and ballet, are blessed with highly developed, broadly accepted training methods. If one follows these methods carefully and diligently, one will almost surely become an expert. I've spent my career studying this second sort of field.

These fields have several characteristics in common. First, there are always objective ways — such as the win/loss of a chess competition or a head-to-head race — or at least semiobjective ways — such as evaluation by expert judges — to measure performance. This makes sense: if there is no agreement on what good performance is and no way to tell what changes would improve performance, then it is very difficult — often impossible — to develop effective training methods. If you don't know for sure what constitutes improvement, how can you develop methods to improve performance? Second, these fields tend to be competitive enough that performers have strong incentive to practice and improve. Third, these fields are generally well established, with the relevant skills having been developed over decades or

even centuries. And fourth, these fields have a subset of performers who also serve as teachers and coaches and who, over time, have developed increasingly sophisticated sets of training techniques that make possible the field's steadily increasing skill level. The improvement of skills and the development of training techniques move forward hand in hand, with new training techniques leading to new levels of accomplishment and new accomplishments generating innovations in training. (The virtuous circle again.) This joint development of skills and training techniques has — up to now at least — always been carried out through trial and error, with a field's practitioners experimenting with various ways to improve, keeping what works and discarding what doesn't.

No field adheres more strongly to these principles than musical training, particularly on the violin and the piano. This is a competitive field and one in which the development of the requisite skills and training methods has been going on for several hundred years. Furthermore, it is an area that, at least in the case of the violin and piano, generally requires twenty or more years of steady practice if you are to take your place among the best in the world.

In short, it is a natural field — and quite likely the very best field — to study for anyone wishing to understand expert performance. And, luckily, it's the field I studied in the years after I had completed my research on expert performance in memory.

In the fall of 1987 I took a position at the Max Planck Institute for Human Development. After finishing my memory studies with Steve Faloon, I had followed up by studying other examples of exceptional memory, such as waiters who could recall the detailed orders of many customers without writing them down and stage actors who had to learn many lines every time they began a new play. In each case I had studied the mental representations that these people developed in order to build their memory, but they all had a major limitation: they were "amateurs" who had undergone no formal training but had just figured it out as they went along. What sorts of achievement might be possible with rigorous, formal training methods? When I moved to Berlin I suddenly had the chance to observe just such methods in musicians.

That opportunity arose thanks to the presence of the Universität der Künste Berlin — or, in English, the Berlin University of the Arts — which is located not far from the Max Planck Institute. The university has thirty-six hundred students in four colleges — a college of fine arts, a college of architecture, a college of media and design, and a college of music and the performing arts — and the music academy in particular is highly regarded for both its teaching and its student body. Its alumni include the conductors Otto Klemperer and Bruno Walter, two giants of twentieth-century conducting, and the composer Kurt Weill, best known for *The Threepenny Opera* and, in particular, for its popular song "Mack the Knife." Year after year the academy turns out pianists, violinists, composers, conductors, and other musicians who go on to take their places among Germany's — and the world's — elite artists.

At the Max Planck Institute, I recruited two collaborators — Ralf Krampe, a graduate student at the institute, and Clemens Tesch-Römer, a postdoctoral fellow there — and together we mapped out an investigation into the development of musical accomplishment. Originally the plan was to focus on the motivations of the music students. In particular, I was curious as to whether musicians' motivations would explain how much practice they engaged in — and thus explain at least in part how accomplished they became.

Ralf, Clemens, and I chose to limit ourselves to the academy's violin students. Because the school was well known for turning out world-class violinists, many of those students would likely rank among the world's best violinists in a decade or two. Not all of them were quite so accomplished, of course. The academy had a range of violin students, from good to very good to great, and this gave us the opportunity to compare the motivation of the various students with their levels of accomplishment.

We first asked the professors at the music academy to identify students who had the potential to have careers as international soloists — the very upper tier of professional violinists. These were the superstars-in-waiting, the students who intimidated all their classmates. The professors came up with fourteen names. Of those, three were not fluent in German — and thus would be difficult to interview — and one was pregnant and wouldn't be able to practice in her normal manner. That left us with ten "best" students — seven women and three men. The professors also identified a number of violin students who were very good but not superstar-good. We chose ten of them and matched them with the first ten by age and sex. These were the "better" students. Finally, we selected another ten age- and sex-matched violinists from the music-education department at the school. These students would most likely end up as music teachers, and while they were certainly skilled musicians when compared to the rest of us, they were clearly less skilled than the violinists in either of the other two groups. Many of the music teachers had unsuccessfully applied to be admitted to the soloist program and then had been accepted into the music-teacher program. This was our "good" group, which gave us three groups that had achieved very different levels of performance: good, better, and best.

We also recruited ten middle-aged violinists from the Berlin Philharmonic Orchestra (now the Berlin Philharmonic) and the Radio-Symphonie-Orchester Berlin, two orchestras with international reputations. The music teachers at the academy had told us that their best students were likely to end up performing in one of these orchestras or in ensembles of similar quality elsewhere in Germany; thus the violinists from these orchestras served as a look to the future — a glimpse of what the best violinists at the music academy were likely to be in another twenty or thirty years.

Our goal was to understand what separated the truly outstanding student violinists from those who were merely good. The traditional view held that differences among individuals performing at these highest levels would be due primarily to innate talent. So differences in the amount and type of practice — in essence, differences in motivation — wouldn't matter at this level. We were looking to see if this traditional view was wrong.

THE CHALLENGE OF THE VIOLIN

It is hard to describe the difficulty of playing a violin — and thus to explain how much skill a good violinist actually has — to someone whose only contact with the violin has been to hear it played by a professional. In the right hands no instrument sounds more beautiful, but put it in the wrong hands and you may as well step on a cat's tail and listen to the sounds that result. Coaxing just a single acceptable note from a violin — one that doesn't screech or squawk or whistle, one that is neither flat nor sharp, one that captures the tone of the instrument — requires a great deal of practice, and learning to play that single note well is just the first step in a long and challenging journey.

The difficulties start with the fact that the violin's fingerboard has no frets, the metal ridges found on a guitar's fingerboard that divide it into separate notes and guarantee that, as long as the guitar is in tune, each note played will sound neither flat nor sharp. Because the violin has no frets, the violinist must put his or her fingers at exactly the right spot on the fingerboard to produce the desired note. A sixteenth of an inch off the mark, and the note will be flat or sharp. If the finger is too far from the correct position, the result is a completely different note from the one that was desired. And that's just one note; every note up and down the fingerboard requires the same precision. Violinists spend countless hours doing scales so that they can move the fingers of their left hand correctly from one note to the next, whether up or down on a single string or moving from one string to another. And once they are comfortable with placing their fingers in exactly the right spots on the fingerboard, there are various subtleties of finger-

ing to master, beginning with vibrato, which is a rolling — not a sliding — of the fingertip up and down the string, which causes the note to shimmer. More hours and hours of practice.

Furthermore, the fingering is actually the easy part. Using the bow properly poses another whole level of difficulty. As the bow is drawn across a string, the horsehair of the bow catches the string and drags it a bit, then lets it slip, catches it again, lets it slip, and so on hundreds or even thousands of times a second, depending on the frequency of the string's vibrations. The particular way that the string moves in response to the bow's drag-and-release action gives the violin its distinctive sound. Violinists control the volume of their playing by varying the pressure of the bow on the string, but that pressure must stay within a certain range; too much and the result is an awful squawking noise, while too little leads to a sound that, while less offensive, isn't considered acceptable. To complicate matters further, the range of acceptable pressures varies according to the bow's position along the string. The closer the bow is to the bridge, the more force is needed to stay within the sweet spot.

Violinists must learn to move the bow across the strings in a variety of ways in order to vary the sound that is produced. The bow can be drawn smoothly across the strings, stopped momentarily, sawed quickly back and forth, picked up and dropped back down on the strings, allowed to bounce gently off the strings, and so on — more than a dozen bowing techniques in all. *Spiccato,* for example, involves bouncing the bow off and back onto a string as the bow moves back and forth across the string, producing a series of short, staccato notes. *Sautillé* is a faster version of *spiccato.* Then there are *jeté, collé, détaché, martelé, legato, louré,* and more, each technique with its own distinctive sound. And, of course, all of these bow techniques must be done in close coordination with the left hand as it fingers the strings.

These are not skills that can be picked up in a year or two of practice. Indeed, all of the students we studied had been playing for well

over a decade — the average age at which they started was eight — and they had all followed the training pattern that is standard for children today. That is, they began systematic, focused lessons very early on, visiting a music teacher usually once a week. During that weekly meeting, the student's current musical performance was evaluated by the teacher, who identified a couple of immediate goals for improvement and assigned some practice activities that a motivated student would be able to attain with solitary practice during the week before the next meeting.

Because most students spend the same amount of time each week with the music teacher — an hour — the primary difference in practice from one student to the next lies in how much time the students devote to solitary practice. Among serious students — such as the ones who ended up in the Berlin academy — it's not unusual for ten- and eleven-year-olds to be spending fifteen hours a week on focused practice, during which time they are following lessons designed by their teachers to develop specific techniques. And as they get older, the serious students generally increase their amount of weekly practice time.

One of the things that differentiates violin training from training in other areas — soccer, for example, or algebra — is that the set of skills expected of a violinist is quite standardized, as are many of the instruction techniques. Because most violin techniques are decades or even centuries old, the field has had the chance to zero in on the proper or "best" way to hold the violin, to move the hand during vibrato, to move the bow during *spiccato,* and so on. The various techniques may not be easy to master, but a student can be shown exactly what to do and how to do it.

All this means is that the violin students at the Universität der Künste Berlin offered a near-perfect opportunity to test the role that motivation plays in developing expert performance and, more generally, to identify what differentiates good performers from the very best.

GOOD VERSUS BETTER VERSUS BEST

To look for these differences, we interviewed each of the thirty student violinists in our study in great detail. We asked them about their musical histories — when they started studying music, who their teachers were, how many hours a week they spent in solitary practice at each age, what competitions they'd won, and so on. We asked them for their opinions on how important various activities were in improving their performance — practicing alone, practicing in a group, playing alone for fun, playing in a group for fun, performing solo, performing in a group, taking lessons, giving lessons, listening to music, studying music theory, and so on. We asked them how much effort these various activities required and how much immediate pleasure they got while they were doing them. We asked them to estimate how much time they'd spent on each of these activities during the previous week. Finally, because we were interested in how much time they'd spent on practice over the years, we asked them to estimate, for each year since they'd started to practice music, how many hours per week on average they had spent in solitary practice.

The thirty music students were also asked to keep daily diaries for each of the next seven days in which they would detail exactly how they'd spent their time. In the diaries, they recorded their activities in fifteen-minute increments: sleeping, eating, going to class, studying, practicing alone, practicing with others, performing, and so on. When they were done we had a detailed picture of how they'd spent their days as well as a very good idea of their practice histories.

The students from all three groups gave similar answers to most of our questions. The students pretty much all agreed, for instance, that solitary practice was the most important factor in improving their performance, followed by such things as practicing with others, taking lessons, performing (particularly in solo performance), listening to music, and studying music theory. Many of them also said that getting enough sleep was very important to their improvement. Because their practice was so intense, they needed to recharge their batteries with a full night's sleep — and often an afternoon nap.

One of our most significant findings was that most factors the students had identified as being important to improvement were also seen as labor-intensive and not much fun; the only exceptions were listening to music and sleeping. Everyone from the very top students to the future music teachers agreed: improvement was hard, and they didn't enjoy the work they did to improve. In short, there were no students who just loved to practice and thus needed less motivation than the others. These students were motivated to practice intensely and with full concentration because they saw such practice as essential to improving their performance.

The other crucial finding was that there was only one major difference among the three groups. This was the total number of hours that the students had devoted to solitary practice.

Using the students' estimates of how many hours a week they'd practiced alone since they'd begun playing the violin, we calculated the total number of hours they'd spent practicing alone until age eighteen, the age at which they typically entered the music academy. Although memories are not always reliable, dedicated students of this sort generally set aside fixed periods to practice each day on a weekly schedule — and they do this beginning very early on in their music training — so we thought it likely that their retrospective estimates of how much time they had spent practicing at various ages would be relatively accurate.

We found that the best violin students had, on average, spent significantly more time than the better violin students had spent, and that the top two groups — better and best — had spent much more time on solitary practice than the music-education students. Specifically, the music-education students had practiced an average of 3,420 hours on the violin by the time they were eighteen, the better violin students had practiced an average of 5,301 hours, and the best violin students had practiced an average of 7,410 hours. Nobody had

been slacking — even the least accomplished of the students had put in thousands of hours of practice, far more than anyone would have who played the violin just for fun — but these were clearly major differences in practice time.

Looking more closely, we found that the largest differences in practice time among the three groups of students had come in the preteen and teenage years. This is a particularly challenging time for young people to keep up their music practice because of the many interests that compete for their time — studying, shopping, hanging out with friends, partying, and so on. Our results indicated that those preteens and teens who could maintain and even increase their heavy practice schedule during these years ended up in the top group of violinists at the academy.

We also calculated estimated practice times for the middle-aged violinists working at the Berlin Philharmonic and the Radio-Symphonie-Orchester Berlin, and we found that the time they had spent practicing before the age of eighteen — an average of 7,336 hours — was almost identical to what the best violin students in the music academy had reported.

There were a number of factors we did not include in our study that could have influenced — and indeed probably *did* influence — the skill levels of the violinists in the different groups. For instance, students who were lucky enough to have worked with exceptional teachers would likely have progressed more quickly than those with teachers who were just okay.

But two things were strikingly clear from the study: First, to become an excellent violinist requires several thousand hours of practice. We found no shortcuts and no "prodigies" who reached an expert level with relatively little practice. And, second, even among these gifted musicians — all of whom had been admitted to the best music academy in Germany — the violinists who had spent significantly more hours practicing their craft were on average more accomplished than those who had spent less time practicing.

The same pattern that we saw among the student violinists has been seen among performers in other areas. Observing this pattern accurately depends on being able to get a good estimate of the total number of hours of practice people have put into developing a skill — which is not always easy to do — and also on being able to tell with some objectivity who the good, better, and best are in a given field, which is also not always easy to do. But when you can do those two things, you generally find that the best performers are those who have spent the most time in various types of purposeful practice.

Just a few years ago I and two colleagues, Carla Hutchinson and Natalie Sachs-Ericsson (who is also my wife), studied a group of ballet dancers to see what role practice played in their achievements. The dancers we worked with were from the Bolshoi Ballet in Russia, the National Ballet of Mexico, and three companies in the United States: the Boston Ballet, the Dance Theatre of Harlem, and the Cleveland Ballet. We gave them questionnaires to learn when they started training and how many hours a week they devoted over time to practice — which consisted mainly of practice time spent in a studio under the direction of an instructor — and we specifically excluded rehearsals and performances. We judged a dancer's skill level by determining what sort of ballet company he or she had performed with — a regional company, such as the Cleveland Ballet, or a national company, such as the Dance Theatre of Harlem, or an international company, such as the Bolshoi or the Boston Ballet — and also by determining the highest level the dancer had reached inside the company, whether a principal dancer, a soloist, or just a member of the troupe. The average age of the dancers was twenty-six, but the youngest was eighteen, so to have an apples-to-apples comparison, we looked at the accumulated amount of practice through age seventeen and the skill level at age eighteen.

Though we were working with fairly crude measures — both of the total hours of practice and of the dancers' abilities — there was still a relatively strong relationship between the reported amount of time

spent on practice and how high a dancer had risen in the world of ballet, with the dancers who practiced more being better dancers, at least according to the troupes they danced with and the positions they held in the troupes. There was no significant difference between dancers from different countries in terms of how many hours of practice they needed to reach a certain level of proficiency.

As with the violinists, the only significant factor determining an individual ballet dancer's ultimate skill level was the total number of hours devoted to practice. When we calculated how much time the dancers had spent on practice through age twenty, we found that they had averaged more than ten thousand hours of practice. Some dancers had put in much more time than this average, however, while others had put in much less, and this difference in training corresponded to the difference between good, better, and best among the dancers. Again, we found no sign of anyone born with the sort of talent that would make it possible to reach the upper levels of ballet without working as hard or harder than anyone else. Other studies of ballet dancers have shown the same thing.

By now it is safe to conclude from many studies on a wide variety of disciplines that nobody develops extraordinary abilities without putting in tremendous amounts of practice. I do not know of any serious scientist who doubts that conclusion. No matter which area you study — music, dance, sports, competitive games, or anything else with objective measures of performance — you find that the top performers have devoted a tremendous amount of time to developing their abilities. We know from studies of the world's best chess players, for example, that almost no one reaches the level of grandmaster with less than a decade of intense study. Even Bobby Fischer, who at the time was the youngest person ever to become a grandmaster and whom many consider to have been the greatest chess player in history, studied chess for nine years before he reached grandmaster level. Since Fischer's achievement, others have achieved grandmaster status at increasingly younger ages, as advances in training and practice methods have made it possible for young players to improve ever more quickly, but it still takes many years of sustained practice to become a grandmaster.

THE PRINCIPLES OF DELIBERATE PRACTICE

In the most highly developed fields — the ones that have benefited from many decades or even centuries of steady improvement, with each generation passing on the lessons and skills it has learned to the next — the approach to individualized practice is amazingly uniform. No matter where you look — musical performance, ballet, or sports such as figure skating or gymnastics — you will find that training follows a very similar set of principles. That study of the Berlin violin students introduced me to this sort of practice, which I named "deliberate practice," and I have since studied it in many other fields. When my colleagues and I published our results on the violin students, we described deliberate practice as follows.

We began by noting that the levels of performance in such areas as musical performance and sports activities have increased greatly over time, and that as individuals have developed greater and more complex skills and performance, teachers and coaches have developed various methods to teach these skills. The improvement in performance generally has gone hand in hand with the development of teaching methods, and today anyone who wishes to become an expert in these fields will need an instructor's help. Because few students can afford a full-time teacher, the standard pattern is to have a lesson once or a few times in a week, with the teachers assigning practice activities the student is expected to perform between lessons. These activities are generally designed with the student's current abilities in mind and are in-

tended to push him or her to move just beyond the current skill level. It was these practice activities that my colleagues and I defined as "deliberate practice."

In short, we were saying that deliberate practice is different from other sorts of purposeful practice in two important ways: First, it requires a field that is already reasonably well developed — that is, a field in which the best performers have attained a level of performance that clearly sets them apart from people who are just entering the field. We're referring to activities like musical performance (obviously), ballet and other sorts of dance, chess, and many individual and team sports, particularly the sports in which athletes are scored for their individual performance, such as gymnastics, figure skating, or diving. What areas don't qualify? Pretty much anything in which there is little or no direct competition, such as gardening and other hobbies, for instance, and many of the jobs in today's workplace — business manager, teacher, electrician, engineer, consultant, and so on. These are not areas where you're likely to find accumulated knowledge about deliberate practice, simply because there are no objective criteria for superior performance.

Second, deliberate practice requires a teacher who can provide practice activities designed to help a student improve his or her performance. Of course, before there can be such teachers there must be individuals who have achieved a certain level of performance with practice methods that can be passed on to others.

With this definition we are drawing a clear distinction between purposeful practice — in which a person tries very hard to push himself or herself to improve — and practice that is both purposeful and *informed.* In particular, deliberate practice is informed and guided by the best performers' accomplishments and by an understanding of what these expert performers do to excel. Deliberate practice is purposeful practice that knows where it is going and how to get there.

In short, deliberate practice is characterized by the following traits:

- Deliberate practice develops skills that other people have already figured out how to do and for which effective training techniques have been established. The practice regimen should be designed and overseen by a teacher or coach who is familiar with the abilities of expert performers and with how those abilities can best be developed.
- Deliberate practice takes place outside one's comfort zone and requires a student to constantly try things that are just beyond his or her current abilities. Thus it demands near-maximal effort, which is generally not enjoyable.
- Deliberate practice involves well-defined, specific goals and often involves improving some aspect of the target performance; it is not aimed at some vague overall improvement. Once an overall goal has been set, a teacher or coach will develop a plan for making a series of small changes that will add up to the desired larger change. Improving some aspect of the target performance allows a performer to see that his or her performances have been improved by the training.
- Deliberate practice is deliberate, that is, it requires a person's full attention and conscious actions. It isn't enough to simply follow a teacher's or coach's directions. The student must concentrate on the specific goal for his or her practice activity so that adjustments can be made to control practice.
- Deliberate practice involves feedback and modification of efforts in response to that feedback. Early in the training process much of the feedback will come from the teacher or coach, who will monitor progress, point out problems, and offer ways to address those problems. With time and experience students must learn to monitor themselves, spot mistakes, and adjust accordingly. Such self-monitoring requires effective mental representations.
- Deliberate practice both produces and depends on effective mental representations. Improving performance goes hand in hand

with improving mental representations; as one's performance improves, the representations become more detailed and effective, in turn making it possible to improve even more. Mental representations make it possible to monitor how one is doing, both in practice and in actual performance. They show the right way to do something and allow one to notice when doing something wrong and to correct it.

- Deliberate practice nearly always involves building or modifying previously acquired skills by focusing on particular aspects of those skills and working to improve them specifically; over time this step-by-step improvement will eventually lead to expert performance. Because of the way that new skills are built on top of existing skills, it is important for teachers to provide beginners with the correct fundamental skills in order to minimize the chances that the student will have to relearn those fundamental skills later when at a more advanced level.

APPLYING THE PRINCIPLES OF DELIBERATE PRACTICE

As defined, deliberate practice is a very specialized form of practice. You need a teacher or coach who assigns practice techniques designed to help you improve on very specific skills. That teacher or coach must draw from a highly developed body of knowledge about the best way to teach these skills. And the field itself must have a highly developed set of skills that are available to be taught. There are relatively few fields — musical performance, chess, ballet, gymnastics, and the rest of the usual suspects — in which all of these things are true and it is possible to engage in deliberate practice in the strictest sense.

But not to worry — even if your field is one in which deliberate practice in the strictest sense is not possible, you can still use the principles of deliberate practice as a guide to developing the most effective sort of practice possible in your area.

For a simple example, let's return once more to memorizing strings of digits. When Steve was working to improve the number of digits he could remember, he was obviously not using deliberate practice to improve. At the time there was no one who could remember forty or fifty digits, and there were records of only a handful of mnemonists who could remember more than fifteen. There were no known training methods, and, naturally, there were no teachers offering lessons. Steve had to figure it out through trial and error.

Today, many people — hundreds or more — train to remember digit strings in order to take part in memory competitions. Some people can recall three hundred and more digits. How do they do it? Not through deliberate practice, at least in its strictest sense. As far as I know, there are no digit-memory instructors out there.

However, something is different today than it was when Steve Faloon was practicing: there are now some well-known techniques for training your memory for long strings of digits. These techniques tend to be variants of the method that Steve developed — that is, they rely on memorizing chunks of two or three or four digits and then arranging those groups in a retrieval structure so that they can be recalled in order later.

I saw such a technique in action when I worked with Yi Hu to study one of the best digit memorizers in the world, Feng Wang of China. At the 2011 World Memory Championships, Feng set what was then the world record by recalling three hundred digits spoken at one per second. Once Professor Hu's assistant had tested Feng's memory encoding technique, it was clear to me that his method was similar to Steve's in spirit but quite different — and much more carefully designed — in its details. Feng based his methods on some of the well-known techniques I mentioned above.

Feng started by developing a set of memorable images that he as-

sociated with each of the hundred pairs of digits from 00 through 99. Next he developed a "map" of physical locations that he could visit in his mind in a very specific order. This is a latter-day version of "the memory palace" that people have used since the time of the ancient Greeks to remember large amounts of information. When Feng hears a string of digits, he takes each set of four numbers, encodes it as a pair of images corresponding to the first two digits in the set and the second two, and mentally places that pair of images in the appropriate location along his mental map. For example, in one trial he encoded the four-digit string 6389 as a banana (63) and a monk (89) and then mentally placed them in a pot; to remember the image, he thought to himself, "There is a banana in the pot, a monk split the banana." Once all of the digits in the list have been read out, Feng recalls the numbers by mentally traveling along the route of his map, remembering which images sat in each location, and then translating those images back into the corresponding numbers. Like Steve before him, Feng is enlisting his long-term memory, creating associations between the numbers in the string and items already in his long-term memory, thus moving far beyond the limitations imposed by short-term memory. But Feng is doing it in a much more sophisticated and effective way than Steve was.

Today's memory competitors can learn from the experiences of those who came before them. They identify the best practitioners — an easy task because it comes down to who can memorize the most digits — and then they determine what enabled these practitioners to perform so well and develop training techniques that will produce those same abilities themselves. While they may lack teachers to design their practice sessions, they can draw on the advice previous experts have recorded in books or interviews. And memory experts will often help others who want to acquire similar skills. Thus, while digit-memory training isn't deliberate practice in its strictest sense, it captures the most important element — learning from the best predecessors — and that has proved enough to generate rapid improvements in the field.

This is the basic blueprint for getting better in any pursuit: get as close to deliberate practice as you can. If you're in a field where deliberate practice is an option, you should take that option. If not, apply the principles of deliberate practice as much as possible. In practice this often boils down to purposeful practice with a few extra steps: first, identify the expert performers, then figure out what they do that makes them so good, then come up with training techniques that allow you to do it, too.

In determining who the experts are, the ideal is to use some objective measure to separate the best from the rest. This is relatively easy in those areas that involve direct competition, such as individual sports and games. It is also reasonably straightforward to pick out the best performers in the performing arts, which, while more dependent on subjective judgments, still involves well-accepted standards for performance and clear expectations for what expert performers do. (When athletes or performers are part of a group, it becomes trickier, but still there are often clear ideas about which individuals are among the best, the middle, or the weakest part of the group.) In other areas, however, it can be quite difficult to identify the true experts. How does one identify, for example, the best doctors or the best pilots or the best teachers? What does it even mean to speak of the best business managers or the best architects or the best advertising executives?

If you are trying to identify the best performers in an area that lacks rules-based, head-to-head competition or clear, objective measures of performance (such as scores or times), keep this one thing at the front of your mind: subjective judgments are inherently vulnerable to all sorts of biases. Research has shown that people are swayed by factors like education, experience, recognition, seniority, and even friendliness and attractiveness when they are judging another person's overall competence and expertise. We have already noted, for instance, how people often assume that more experienced doctors are better than less experienced ones, and people also assume that someone with several degrees will be more competent than someone with one or none. Even

in the judgment of musical performance, which should be more objective than in most fields, research has shown that judges can be influenced by such irrelevant factors as the performer's reputation, sex, and physical attractiveness.

In many fields, people who are widely accepted as "experts" are actually not expert performers when judged by objective criteria. One of my favorite examples of this phenomenon concerns wine "experts." Many of us assume that their highly developed palates can pick out subtleties and nuances in wines that are not apparent to the rest of us, but studies have shown that their powers are highly exaggerated. For example, while it has long been known that the ratings given to individual wines often vary widely from expert to expert, a 2008 article in the *Journal of Wine Economics* reported that wine experts don't even agree with themselves.

Robert Hodgson, the owner of a small California winery, got in touch with the head judge of the annual wine competition at the California State Fair, in which thousands of wines are entered each year, and suggested an experiment. The competition is set up so that each judge tastes a flight of thirty wines at a time. The wines are not identified, so the judge cannot be influenced by reputation or other factors. Hodgson suggested that in a number of those flights, the judges should be given three samples of the same wine. Would they give these identical samples the same rating, or would their ratings vary?

The head judge agreed, and Hodgson ran this experiment at four consecutive state fairs from 2005 to 2008. He found that very few judges rated the three identical samples similarly. It was common for a judge to give scores that varied by plus or minus four points — that is, to give one sample a 91, a second sample of the same wine an 87, and the third an 83. This is a significant difference: a 91 wine is a good wine that will fetch a premium price, while an 83 is nothing special. Some judges determined one of the three samples to be worthy of a gold medal and another of the three to be worth just a bronze medal — or no medal at all. And while in any given year some judges were more

consistent than others, when Hodgson compared them year to year, he found that judges who were consistent one year were inconsistent the next. None of the judges — and these were sommeliers, wine critics, winemakers, wine consultants, and wine buyers — proved to be consistent all the time.

Research has shown that the "experts" in many fields don't perform reliably better than other, less highly regarded members of the profession — or sometimes even than people who have had no training at all. In his influential book *House of Cards: Psychology and Psychotherapy Built on Myth,* the psychologist Robyn Dawes described research showing that licensed psychiatrists and psychologists were no more effective at performing therapy than laypeople who had received minimal training. Similarly, many studies have found that the performance of financial "experts" in picking stocks is little or no better than the performance of novices or random chance. And, as we noted earlier, doctors in general practice with several decades of experience sometimes perform worse, when judged by objective measures, than doctors with just a few years of experience — mainly because the younger doctors attended medical school more recently, so their training is more up-to-date and they are more likely to remember it. Contrary to expectations, experience doesn't lead to improved performance among many types of doctors and nurses.

The lesson here is clear: be careful when identifying expert performers. Ideally you want some objective measure of performance with which to compare people's abilities. If no such measures exist, get as close as you can. For example, in areas where a person's performance or product can be observed directly — a screenwriter, say, or a programmer — the judgment of peers is a good place to start, while keeping in mind the possible influence of unconscious bias. However, many professionals, including doctors, psychotherapists, and teachers, work mostly by themselves, and other professionals in their field may know little about their practices or about their outcomes with patients and students. Thus a good rule of thumb is to seek out people who

work intimately with many other professionals, such as a nurse who plays a role on several different surgery teams and can compare their performance and identify the best. Another method is to seek out the persons that professionals themselves seek out when they need help with a particularly difficult situation. Talk to the people about who they think are the best performers in their field, but be certain that you ask them what type of experience and knowledge they have to be able to judge one professional as being better than another.

In a field you're already familiar with — like your own job — think carefully about what characterizes good performance and try to come up with ways to measure that, even if there must be a certain amount of subjectivity in your measurement. Then look for those people who score highest in the areas you believe are key to superior performance. Remember that the ideal is to find objective, reproducible measures that consistently distinguish the best from the rest, and if that ideal is not possible, approximate it as well as you can.

Once you've identified the expert performers in a field, the next step is to figure out specifically what they do that separates them from other, less accomplished people in the same field, and what training methods helped them get there. This is not always easy. Why does one teacher improve students' performances more than another? Why does one surgeon have better outcomes than another? Why does one salesperson consistently make more sales than another? You can generally bring an expert in the field in to observe the performance of various individuals and make suggestions about what they are doing well and what they need to improve on, but it may not be obvious, even to experts, exactly what differentiates the best performers from everyone else.

Part of the problem is the key role that mental representations play. In many fields it is the quality of mental representations that sets apart the best from the rest, and mental representations are, by their nature, not directly observable. Consider once more the task of memorizing strings of digits. Someone who watched a film of Steve Faloon repeating back a string of eighty-two digits and then saw Feng Wang doing three hundred would obviously know who was better, but there would be no way to know why. I myself know why, because having spent two years collecting verbal reports on Steve's thought processes and designing experiments to test ideas about his mental representations, I was able to use the same methods when my colleague Yi Hu and I studied Feng Wang. Having studied half a dozen memory experts' mental representations made it easier for me to identify the critical differences between Steve and Feng, but this is the exception rather than the rule. Even psychology researchers are only now just beginning to explore the role of mental representations in understanding why some people perform so much better than others, and there are very few areas in which we can say with certainty, "Here are the types of mental representations that the expert performers in the field use, and this is why they are more effective than other sorts of mental representations that one might use." If you have a psychological bent, it may be worthwhile to talk to the expert performers and try to get a sense of how they approach tasks and why. Even with that approach, however, you're likely to uncover just a small part of what makes them special, for often even they don't know. We'll discuss more about this in chapter 7.

Fortunately, in some cases you can bypass figuring out what sets experts themselves apart from others and simply figure out what sets their training apart. For instance, in the 1920s and 1930s the Finnish runner Paavo Nurmi set twenty-two world records in distances from 1,500 meters (just under a mile) to 20 kilometers (just under 12.5 miles). For a few years he was untouchable at any distance he chose to train for; everyone else was competing for second place. But eventually other runners realized that Nurmi's advantage came from having developed new training techniques, such as pacing himself with a stopwatch, using interval training to build speed, and following a year-long training regimen so that he was always training. Once those techniques were widely adopted, it elevated the performance of the entire field.

Lesson: Once you have identified an expert, identify what this person does differently from others that could explain the superior performance. There are likely to be many things the person does differently that have nothing to do with the superior performance, but at least it is a place to start.

In all of this keep in mind that the idea is to inform your purposeful practice and point it in directions that will be more effective. If you find that something works, keep doing it; if it doesn't work, stop. The better you are able to tailor your training to mirror the best performers in your field, the more effective your training is likely to be.

And finally remember that, whenever possible, the best approach is almost always to work with a good coach or teacher. An effective instructor will understand what must go into a successful training regimen and will be able to modify it as necessary to suit individual students.

Working with such a teacher is particularly important in areas like musical performance or ballet, where it takes ten-plus years to become an expert and where the training is cumulative, with the successful performance of one skill often depending on having previously mastered other skills. A knowledgeable instructor can lead the student to develop a good foundation and then gradually build on that foundation to create the skills expected in that field. In learning the piano, for instance, a student must have proper finger placement from the start, for while it may be possible to play simpler pieces with the fingers not in their ideal positions, more complicated pieces will demand that the student have developed proper habits. An experienced teacher will understand this; no student, no matter how motivated, can expect to figure out such things on his or her own.

Finally, a good teacher can give you valuable feedback you couldn't get any other way. Effective feedback is about more than whether you did something right or wrong. A good math teacher, for instance, will look at more than the answer to a problem; he'll look at exactly how the student got the answer as a way of understanding the mental representations the student was using. If needed, he'll offer advice on how to think more effectively about the problem.

NO, THE TEN-THOUSAND-HOUR RULE ISN'T REALLY A RULE

Ralf Krampe, Clemens Tesch-Römer, and I published the results from our study of the Berlin violin students in 1993. These findings would go on to become a major part of the scientific literature on expert performers, and over the years a great many other researchers have referred to them. But it was actually not until 2008, with the publication of Malcolm Gladwell's *Outliers,* that our results attracted much attention from outside the scientific community. In his discussion of what it takes to become a top performer in a given field, Gladwell offered a catchy phrase: "the ten-thousand-hour rule." According to this rule, it takes ten thousand hours of practice to become a master in most fields. We had indeed mentioned this figure in our report as the average number of hours that the best violinists had spent on solitary practice by the time they were twenty. Gladwell himself estimated that the Beatles had put in about ten thousand hours of practice while playing in Hamburg in the early 1960s and that Bill Gates put in roughly ten thousand hours of programming to develop his skills to a degree that allowed him to found and develop Microsoft. In general, Gladwell suggested, the same thing is true in essentially every field of human endeavor—people don't become expert at something until they've put in about ten thousand hours of practice.

The rule is irresistibly appealing. It's easy to remember, for one thing. It would've been far less effective if those violinists had put in, say, eleven thousand hours of practice by the time they were twenty. And it satisfies the human desire to discover a simple cause-and-effect relationship: just put in ten thousand hours of practice at anything, and you will become a master.

Unfortunately, this rule — which is the only thing that many people today know about the effects of practice — is wrong in several ways. (It is also correct in one important way, which I will get to shortly.) First, there is nothing special or magical about ten thousand hours. Gladwell could just as easily have mentioned the average amount of time the best violin students had practiced by the time they were eighteen — approximately seventy-four hundred hours — but he chose to refer to the total practice time they had accumulated by the time they were twenty, because it was a nice round number. And, either way, at eighteen or twenty, these students were nowhere near masters of the violin. They were very good, promising students who were likely headed to the top of their field, but they still had a long way to go when I studied them. Pianists who win international piano competitions tend to do so when they're around thirty years old, and thus they've probably put in about twenty thousand to twenty-five thousand hours of practice by then; ten thousand hours is only halfway down that path.

And the number varies from field to field. Steve Faloon became the very best person in the world at memorizing strings of digits after only about two hundred hours of practice. I don't know exactly how many hours of practice the best digit memorizers put in today before they get to the top, but it is likely well under ten thousand.

Second, the number of ten thousand hours at age twenty for the best violinists was only an average. Half of the ten violinists in that group hadn't actually accumulated ten thousand hours at that age. Gladwell misunderstood this fact and incorrectly claimed that *all* the violinists in that group had accumulated over ten thousand hours.

Third, Gladwell didn't distinguish between the deliberate practice that the musicians in our study did and any sort of activity that might be labeled "practice." For example, one of his key examples of the ten-thousand-hour rule was the Beatles' exhausting schedule of performances in Hamburg between 1960 and 1964. According to Gladwell, they played some twelve hundred times, each performance lasting as much as eight hours, which would have summed up to nearly ten

thousand hours. *Tune In,* an exhaustive 2013 biography of the Beatles by Mark Lewisohn, calls this estimate into question and, after an extensive analysis, suggests that a more accurate total number is about eleven hundred hours of playing. So the Beatles became worldwide successes with far less than ten thousand hours of practice. More importantly, however, performing isn't the same thing as practice. Yes, the Beatles almost certainly improved as a band after their many hours of playing in Hamburg, particularly because they tended to play the same songs night after night, which gave them the opportunity to get feedback — both from the crowd and themselves — on their performance and find ways to improve it. But an hour of playing in front of a crowd, where the focus is on delivering the best possible performance at the time, is not the same as an hour of focused, goal-driven practice that is designed to address certain weaknesses and make certain improvements — the sort of practice that was the key factor in explaining the abilities of the Berlin student violinists.

A closely related issue is that, as Lewisohn argues, the success of the Beatles was not due to how well they performed other people's music but rather to their songwriting and creation of their own new music. Thus, if we are to explain the Beatles' success in terms of practice, we need to identify the activities that allowed John Lennon and Paul McCartney — the group's two primary songwriters — to develop and improve their skill at writing songs. All of the hours that the Beatles spent playing concerts in Hamburg would have done little, if anything, to help Lennon and McCartney become better songwriters, so we need to look elsewhere to explain the Beatles' success.

This distinction between deliberate practice aimed at a particular goal and generic practice is crucial because not every type of practice leads to the improved ability that we saw in the music students or the ballet dancers. Generally speaking, deliberate practice and related types of practice that are designed to achieve a certain goal consist of individualized training activities — usually done alone — that are devised specifically to improve particular aspects of performance.

The final problem with the ten-thousand-hour rule is that, although Gladwell himself didn't say this, many people have interpreted it as a promise that almost anyone can become an expert in a given field by putting in ten thousand hours of practice. But nothing in my study implied this. To show a result like this, I would have needed to put a collection of randomly chosen people through ten thousand hours of deliberate practice on the violin and then see how they turned out. All that our study had shown was that among the students who had become good enough to be admitted to the Berlin music academy, the best students had put in, on average, significantly more hours of solitary practice than the better students, and the better and best students had put in more solitary practice than the music-education students.

The question of whether anyone can become an expert performer in a given field by taking part in enough designed practice is still open, and I will offer some thoughts on this issue in the next chapter. But there was nothing in the original study to suggest that it was so.

Gladwell did get one thing right, and it is worth repeating because it's crucial: becoming accomplished in any field in which there is a well-established history of people working to become experts requires a tremendous amount of effort exerted over many years. It may not require exactly ten thousand hours, but it will take a lot.

We have seen this in chess and the violin, but research has shown something similar in field after field. Authors and poets have usually been writing for more than a decade before they produce their best work, and it is generally a decade or more between a scientist's first publication and his or her most important publication — and this is in addition to the years of study before that first published research. A study of musical composers by the psychologist John R. Hayes found that it takes an average of twenty years from the time a person starts studying music until he or she composes a truly excellent piece of music, and it is generally never less than ten years. Gladwell's ten-thousand-hour rule captures this fundamental truth — that in many areas of human endeavor it takes many, many years of practice to become

one of the best in the world — in a forceful, memorable way, and that's a good thing.

On the other hand, emphasizing what it takes to become one of the best in the world in such competitive fields as music, chess, or academic research leads us to overlook what I believe to be the more important lesson from our study of the violin students. When we say that it takes ten thousand — or however many — hours to become really good at something, we put the focus on the daunting nature of the task. While some may take this as a challenge — as if to say, "All I have to do is spend ten thousand hours working on this, and I'll be one of the best in the world!"— many will see it as a stop sign: "Why should I even try if it's going to take me ten thousand hours to get really good?" As Dogbert observed in one *Dilbert* comic strip, "I would think a willingness to practice the same thing for ten thousand hours is a mental disorder."

But I see the core message as something else altogether: In pretty much any area of human endeavor, people have a tremendous capacity to improve their performance, as long as they train in the right way. If you practice something for a few hundred hours, you will almost certainly see great improvement — think of what two hundred hours of practice brought Steve Faloon — but you have only scratched the surface. You can keep going and going and going, getting better and better and better. How much you improve is up to you.

This puts the ten-thousand-hour rule in a completely different light: The reason that you must put in ten thousand or more hours of practice to become one of the world's best violinists or chess players or golfers is that the people you are being compared to or competing with have themselves put in ten thousand or more hours of practice. There is no point at which performance maxes out and additional practice does not lead to further improvement. So, yes, if you wish to become one of the best in the world in one of these highly competitive fields, you will need to put in thousands and thousands of hours of hard, focused work just to have a chance of equaling all of those others who have chosen to put in the same sort of work.

One way to think about this is simply as a reflection of the fact that, to date, we have found no limitations to the improvements that can be made with particular types of practice. As training techniques are improved and new heights of achievement are discovered, people in every area of human endeavor are constantly finding ways to get better, to raise the bar on what was thought to be possible, and there is no sign that this will stop. The horizons of human potential are expanding with each new generation.

5

Principles of Deliberate Practice on the Job

IT WAS 1968, AND THE VIETNAM WAR was in full swing. U.S. fighter pilots from the navy and air force were regularly engaging Soviet-trained North Vietnamese airmen flying Russian-made MiG fighter planes in dogfights, and the Americans weren't doing so well. In the previous three years, the pilots of both the navy and the air force had been winning about two-thirds of their dogfights: they downed two North Vietnamese jets for every one jet they lost. But in the first five months of 1968 the ratio for the navy pilots had dropped down to about one-to-one: the U.S. Navy had shot down nine MiGs, but lost ten of its own jets. Furthermore, over the summer of 1968, navy pilots had fired more than fifty air-to-air missiles without shooting down a single MiG. The navy's brass decided that something had to be done.

That something turned out to be the establishment of the now-famous Top Gun school, properly known as the U.S. Navy Strike Fighter Tactics Instructor Program (and originally the U.S. Navy Fighter Weapons School). The school would teach navy pilots how to