Performing from Memory Doesn't Have to be Terrifying: How Understanding the Science of Memory Can Help

Molly Gebrian

The tradition of performing from memory is a relatively recent one. When Clara Schumann performed the Beethoven Piano Sonata op. 57 from memory in 1837 (at age 17), it marked a turning point in solo performance practice. Musicians had performed from memory before this, but it was considered arrogant and actively discouraged. By the end of the 19th century, however, it became unusual to see pianists in particular performing *with* the score.[1] Today, of course, this is a standard part of live performance. But nothing is more terrifying to performers than the prospect of having a memory slip. Understanding the science of memory can help us prepare better for live performance and significantly reduce the likelihood that our knowledge of the music will desert us when we get on stage.

We tend to think of memory as a unitary concept, but there are actually many different types of memory, all of which are distinct and separate from each other (fig. 1). One division in memory is between explicit (or declarative) memory and implicit (or procedural) memory. An aspect of implicit memory is what musicians call "muscle memory"—the memory of how to do something, which does not require conscious awareness. Your enduring ability to ride a bike, even if you have not done so for many years, is because of implicit memory. Most likely, you cannot explain very well how to ride a bike—you just know how to do it. On the other hand, explicit memory consists of your knowledge of the world and your own experiences. This type of memory can be further divided into two types: semantic memory (memory for facts, concepts, and ideas) and episodic/autobiographical memory (memory for specific events that you have experienced). These memories are explicit because you are consciously aware of them, and could write them down or explain them to someone else.

Both explicit and implicit memory belong to our long-term memory store, yet another division in the way the brain handles memory. These are memories we have acquired at an earlier time in our life that are stored in our brain in a relatively stable manner so that we can recall them, on demand, whenever we want. Opposite this is short-term memory: the type of memory you use when trying to remember a phone number if you don't have a way to write it down. If you get distracted before you write it down, you will likely forget the number because short-term memory storage is very fragile and short-lived. In addition to long- and short-term memory, we also use something called working memory. Working memory allows us to simultaneously hold information in mind and use it at the same time. When you sight-read, you call on working memory to remember and execute any accidentals present in the bar; since these get reset at the bar line, you have to constantly update your memory of what notes have received modifications. Working memory is very taxing for the brain, has limited capacity, and tends to break down under pressure, an idea we will return to below. Understanding that these different types of memory exist and how they function differently is critical to training yourself to perform from memory confidently and consistently.

When a musician performs from memory, they are calling on several different forms of memory at once, all of which must work together seamlessly. We rely on *implicit memory* (motor memory) for fingerings, bowings, etc.: how does it feel to play this piece? We rely on our *auditory memory*: how does this piece sound? And we rely on *explicit semantic memory*: what is the structure of this piece? What are the actual notes, rhythms, dynamics, etc.? For most of us, one of these three is stronger than the others and comes more easily. But if we only rely on

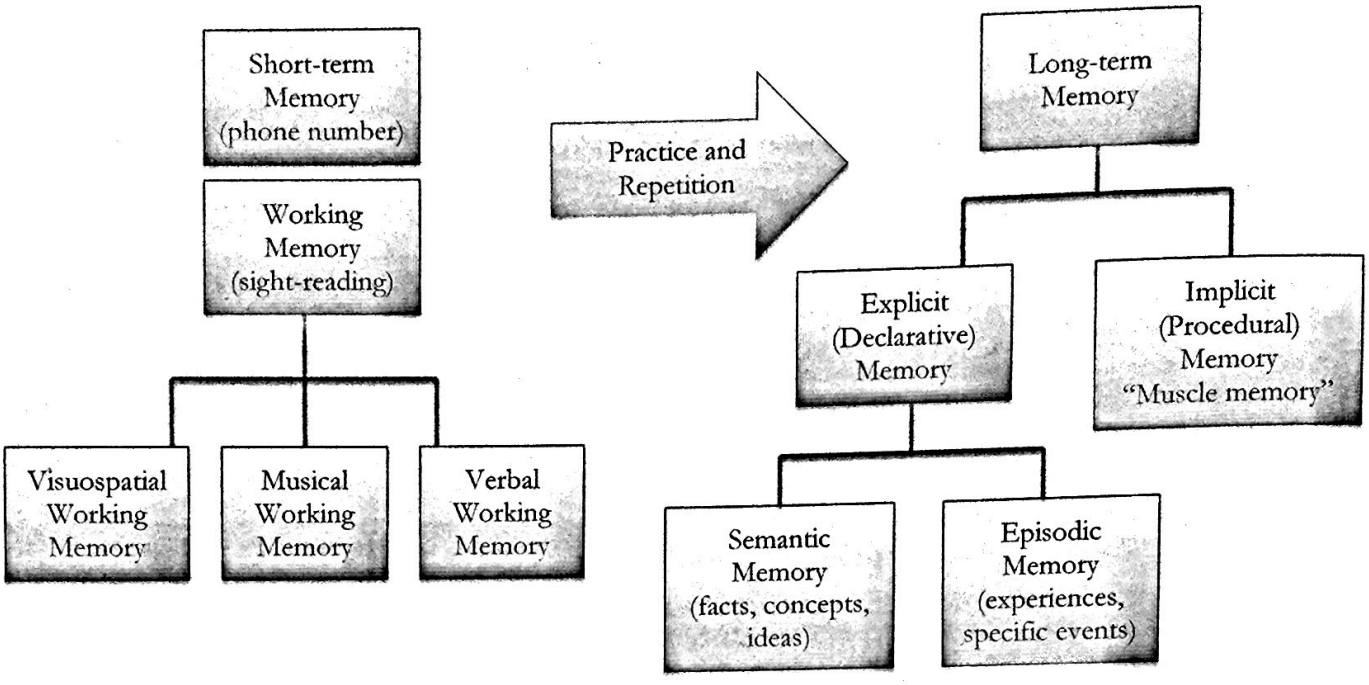

Figure 1. Different types of memory.

one type of memory and it breaks down when we are on stage, we have nothing to fall back on. We need to make sure all three types of memory are equally strong, both so that we have a back up in case one system fails, but also because they all reinforce each other.

In addition to different types of memory, researchers have identified three different stages of memorization: encoding, consolidation, and retrieval. Encoding is how information gets into your brain: if encoding is weak or inefficient, retrieval will be difficult to impossible. Consolidation is how information makes its way from temporary memory stores to more permanent, long-term stores. Sleep appears to be critical to this process. Retrieval is how you get information back out again when you want to use it. If retrieval hasn't been practiced well, this will make remembering on demand very difficult.

One of the most consistent findings on encoding is that deeper encoding makes for better retrieval: deeper in this case means elaborating on the information to be learned and connecting it to what you already know. A classic study on encoding asked research subjects to look at a word list. Some had to say the last letter in each word, while others were asked to give a definition for each word.[2] Later, they were given a pop quiz to see how many of the words the remembered. Those who had defined the words were able to remember many more from the list because encoding had been deeper for them. On the retrieval side, the best way to improve retrieval is to . . . practice retrieving. This may sound like a truism, but said another way: the best way to study for a test is to take a test. When you your brain has to come up with information from scratch, this further solidifies the information in your mind, making it that much easier to remember the next time. For remembering facts, reading over your notes is not going to do much to help you on the test because you are not practicing retrieval. Taking a practice test is much more effective. For music, playing with the music over and over again isn't as effective as forcing yourself to play from memory to see what you remember and what you don't. To make sure our muscle memory, auditory memory, and explicit semantic memory of the score are all equally strong, we need to be certain that we encode each one equally well and that we've practiced retrieving each one, independently from the others, particularly for whichever type of memory is weakest.

Chunking

The scientific research on memorization provides many insights on how to improve each stage of the memorization process. One of the most consistent and powerful findings is on the importance of chunking: packaging information into meaningful units, rather than memorizing isolated, discrete pieces of information. For instance, put on a timer and give yourself five seconds to

memorize the following letters: I B F A S U A I C. Now give yourself five seconds to memorize these letters: C I A U S A F B I. The second list was likely much easier. Why? The second list is three acronyms you already know: CIA USA FBI. It's three pieces of information, rather than nine pieces, and you can easily connect each one to information you already have stored in your long-term memory. The first list was seemingly just random letters (it's actually the second list backwards), and therefore much more information to retain. Research on experts in many different fields emphasizes the importance of chunking, particularly for feats of memorization. When a novice has to perform a memorization task, they don't have any information chunks yet and researchers have found that activity in areas of the brain involved with working memory is very high. As the novice gains expertise, chunks are formed, and activity in working memory areas goes down, while activity in long-term memory areas goes up. At the expert level, even more information is contained in the chunks (called knowledge structures), and these knowledge structures are housed in long-term memory stores. When an expert performs a memory task, they have much less activity in working-memory areas and much more activity in long-term memory areas. This is why experts in a particular field seem to perform memory feats so effortlessly: as mentioned before, working memory is very taxing for the brain and tends to break down under pressure. It also has a limited capacity. Experts are essentially able to vastly augment their working memory store because they can pull from extensive knowledge and experience stored in their long-term memory.[3]

This, in a nutshell, is why we practice technique and why we study music theory. Practicing scales, arpeggios, exercises, etc. helps us create larger, more detailed, and more flexible chunks (motor memory chunks, auditory memory chunks, and explicit memory chunks) that we can store in our long-term memory. A child just learning to play viola likely doesn't know what an arpeggio is yet, and so the opening four notes of May Song (D–F-sharp–A–D) may be difficult to remember because they are four separate, unrelated notes. For someone more advanced, it's trivial because it's just a D major arpeggio. Studying music theory (i.e. how notes work together and the relationship between keys and harmonies) allows us to know what to expect, enabling us to fit the music into a larger framework. This is also the reason why contemporary music may appear more difficult to memorize: we don't have pre-established chunks for the language of the particular piece we are working on, so we have to create new chunks. But for all kinds of music, as much as we can group notes into larger patterns, the easier it will be to play and remember.

The importance of musical structure

Knowledge of music theory and the structure of the piece we are trying to memorize can also help us in other ways. Since antiquity, one of the most commonly used mnemonic devices is called the method of loci. In this strategy, the learner is asked to remember a familiar route (their drive to work, the layout of their home) and to mentally place each item to be remembered at various spots along the route that will trigger their memory for the item. Then, to remember each item, the person mentally walks through the route, passing each item as they go. In music, we have a built-in method of loci: the structure of the piece itself.

Roger Chaffin, a psychologist at the University of Connecticut, has done extensive studies on musicians preparing for memorized performance and his research reinforces the importance of using the form of the piece to aid memory. In many of his studies, he works with a single professional musician who is proficient at performing from memory to document the process of preparing a piece for memorized performance. Through his analysis of this process, he has identified four different performance cues that professional musicians use to trigger memory: *structural cues* (drawn from the formal structure of the piece: the recapitulation, the beginning of the second theme, etc.), *expressive cues* (the emotions the performer wants to express at a particular part of the music), *interpretive cues* (changes in tempo, dynamics, etc.), and *basic cues* (technical issues like fingering or bowing). Around two years after each study, he surprises each musician with a pop quiz: write out the entire piece from memory. What he has found is that the most durable memory cues are structural cues and expressive cues. These are the best at cueing recall for the actual notes and rhythms of the piece. Interestingly, basic cues (fingerings, bowings, etc.) are the weakest cues and may even negatively impact performance in some cases.[4]

All of the musicians he has worked with emphasize the importance of knowing exactly where they are in the piece at all times so that if something goes wrong in

performance, they can get right back on. Often young children learning an instrument will say they can only start at the beginning of the piece. This is because they only know it by rote and if they make a mistake in the middle, they won't be able to keep going. The musicians Chaffin studied also emphasized the importance of practicing the retrieval of their performance cues so that this recall is instantaneous and automatic. Often, not enough time is given to practicing playing from memory, which means our retrieval structure is not in long-term memory and therefore likely to break down under pressure.

Start memorizing early

So when should we start practicing from memory? A study done by Jane Ginsborg in 2002 looking at classically trained singers suggests the earlier the better.[5] She recruited a mix of students, amateurs, and professional singers to learn a new song over the course of six 15-minute practice sessions. At the final session, they had to perform as much as they could from memory. She found that the singers could be divided into two groups: fast, accurate memorizers and slow, inaccurate memorizers. Interestingly, there were students, amateurs, and professionals in each group. The most important finding from this study is that the accurate memorizers started testing their memory in the very first practice session. They only attempted to sing a little bit from memory, but they attempted *something*. In the second session, they attempted much more from memory. The inaccurate memorizers only began to test their memory in the second session, and attempted much less than the accurate memorizers had in the first session. The accurate memorizers made more errors early on than the inaccurate memorizers, but by the final session, they were able to perform the song from memory much more accurately than the inaccurate memorizers were, by a very wide margin. This is because the accurate memorizers had more opportunity to practice retrieval and to test their memory, correcting mistakes early on. Waiting until a week or so before a concert to start playing from memory is a mistake. Playing something, even one bar, from memory during the very first practice session will pay off in the performance.

The benefits of interleaved practice

Another aid to memory is interleaved (or random) practice. I wrote an entire article on this for the Fall 2016 issue of this journal (volume 32, no. 2)[6] and I encourage interested readers to refer to that article for a more comprehensive understanding of this practice strategy. Briefly, massed (or blocked) practice is the method of playing something over and over again, or for a long block of time. Random (or interleaved) practice asks the practicer to switch quickly between different tasks. This type of practicing simulates a performance much more closely because it requires the brain to reconstruct from scratch exactly how to play a given passage, without getting to do it a couple of times to "get it back in the fingers." This method of practicing has been shown, repeatedly, to result in better performance success. There are several ways to use this idea to help memorization. First, don't always start from the beginning when practicing playing from memory. Start in various places throughout the piece to make sure you can start anywhere. Second, in the middle of practicing something completely unrelated, switch to playing, from memory, the piece you are trying to memorize, either a portion of it or all of it. Do this starting at various points in the piece. You can use an interval timer to do this more systematically (described in the Fall 2016 article), or you can just switch gears whenever you feel like it.

The role of sleep

The final insight on improving memory comes from the field of sleep research. During the day, information we are attempting to learn is stored in the hippocampus, a structure in the middle of the brain, one in each hemisphere. The hippocampus has limited storage, so at night while we sleep, the information in the hippocampus is transferred to the neocortex (the bumpy outer part of the brain) for more permanent storage. This is the process of consolidation, the middle stage of memory formation. If we don't sleep, this information is not transferred and it gets lost. For motor memories, this transfer happens during REM sleep. For declarative memories, this happens during non-REM (NREM) sleep. Sleep researchers define a full night of sleep as eight hours and getting any less than that will mean getting less REM and/or NREM sleep than the brain actually needs and memory consolidation will suffer as a result. In addition to this transfer of memory storage, it is well known

that performance improves following a night of sleep. Matthew Walker and his colleagues found, in a series of studies in the early 2000s, that if they trained people to do a motor task and then sent them home to sleep, the next morning they would be much faster and more accurate than they had been the night before. It didn't matter how many times they practiced on day 1: there was always a big boost in performance on day 2.[7]

Sarah Allen decided to test this on pianists learning to memorize a brief melody.[8] She also wanted to see if memorizing two melodies at once impaired memorization in any way, using four different groups of pianists. Group 1 worked on memorizing melody A, went home to sleep, and in the morning were tested on how well they could play melody A from memory. Group 2 worked on melody A, but then worked on memorizing melody B. They went home to sleep and in the morning their memory for melody A was tested. Group 3 learned melody A and melody B like group 2, but then they got a mini-practice session on melody A once more before sleeping. In the morning, they performed melody A. Group 4 learned melody A, went home and went to sleep and then came back in the morning and learned melody B. After that, they were tested on their memory for melody A.

Group 1 (melody A, sleep, melody A) showed a boost in performance just like in Matthew Walker's studies. When they came back in the morning, their memory for melody A was better than it had been the day before. Group 2 (melody A, melody B, sleep, melody A) showed no overnight improvement: they were the same the next day as they were when they left. Group 4 (melody A, sleep, melody B, melody A) showed the same result as group 2: no increase in performance. Interestingly, group 3 (melody A, melody B, short refresher on melody A, sleep, melody A) *did* show improved performance the next day, just like group 1. This means that you will enhance your memory if you practice something last thing in the day and then first thing the next morning, before you practice anything else. Obviously, musicians are often working on several pieces simultaneously, but this is a good strategy for that especially tricky passage that just won't stick with you.

Auditory/motor connection

Trying any one of these strategies will improve your ability to perform from memory. Doing all of them will drastically improve your abilities. At the beginning of the article, I noted that performing from memory relies on muscle (implicit) memory, auditory memory, and explicit semantic memory and that it is important to strengthen all of these. In addition to the strategies discussed above, there are specific activities you can incorporate into your practice that will target each of these areas individually.

For improving muscle memory, put on headphones (with no music playing) and finger through your piece while playing "air bow." The point of the headphones is so that you don't hear the pitch that your fingers will produce while tapping on the strings. Peter Slowik at Oberlin Conservatory advises detuning your instrument and then playing from memory this way. It sounds terrible, so it's a real test of your muscle memory! To test your auditory memory, practice singing from memory out loud (even better: do it on solfege). To practice explicit semantic memory, practice writing out the score from memory.

One final thing you can do that will strengthen both auditory and motor memory is to finger silently while you sing out loud. Carol Rodland at Juilliard also advocates saying aloud solfege, finger number, and/or note name, or singing each note out loud before playing it. These strategies will help associate the sounds with how it feels to make them. In fact, this auditory/motor connection seems to be a hallmark of professional musicians. Martin Lotze and his colleagues took a group of violinists, both amateurs and professionals, and had them play the opening of Mozart's Third Violin Concerto silently from memory in an fMRI machine (which shows the areas of the brain that are active when someone is doing a particular task). What they found was that even though there was no sound, the auditory cortex was active in the professional musicians, but not the amateurs.[9] In a related study in 2001, Haueisen and Knösche found that when professional pianists listened to a piece they knew how to play, their motor cortex was active exactly as it would be had they actually been playing.[10] Practicing to help forge this connection between the auditory and motor areas of our brain will increase our ability to play from memory because the auditory becomes a cue for the motor information and vice versa.

Preventing memory slips

A performer's worst fear when performing from memory is that they will have a memory slip and go blank in front of hundreds of people, unable to continue performing. All of the strategies discussed above are very protective against memory slips. The world of sports research, however, has done a lot of work investigating what makes someone "choke" under pressure and how to prevent it. When the phenomenon of choking (that is, performing worse under pressure, despite good preparation and ability) was first being investigated, there were two theories as to why this happens: 1) distraction: pressure distracts from the task at hand and overwhelms working memory; or 2) explicit monitoring: thinking explicitly about each individual component of executing the skill instead of relying on implicit memory (muscle memory). To determine the culprit, researchers did a series of experiments. If it is due to distraction, having someone do a distracting task while they perform under pressure should make them do worse. If it is due to explicit monitoring, videotaping the person and telling them that the video would be sent to a top coach in their field to evaluate their form should make them do worse because it would cause them to focus on and monitor each individual component of the skill even more. The verdict? Researchers have consistently found that providing a distraction actually helps people do *better* under pressure, whereas increasing their self-consciousness by video recording causes them to do worse, so it seems that explicit monitoring is the culprit.[11]

Of course, the minute to tell yourself *not* to think about something, that is all you will think about. Telling yourself not to think about each individual note, or exactly where your fingers should go when you are on stage will cause you to fixate on precisely these things. Researchers have found that a powerful way to protect against explicit monitoring during performance is to video record your practice sessions.[12] This enables you to get used to the idea of being watched so it won't affect you so much in performance.

Having athletes think in terms of analogies and of things outside themselves (rather than paying attention to internal processes) also helped protect against choking. For us, this means thinking about expression, sound, phrasing and bigger picture musical things, rather than fixating on every single note we are playing. This

is probably advice you have heard before, but now we know why: fixating on individual notes and technique while performing will make it more likely that you will get in the way of automatic memory processes. But like anything else, it is imperative to *practice* thinking this when you play from memory in the practice room. You can't expect this way of thinking will kick in when you get on stage if you haven't practiced it beforehand.

The big picture

Memory is a complex and multifaceted aspect of cognition. From encoding to consolidation to retrieval to protecting against memory slips, here is a list important advice to remember:

- Study your score.
- Practice playing from memory early in the learning process.
- Get enough sleep.
- Practice what you are trying to memorize last in the day and then first thing the next morning.
- Use interleaved practice to test your memory.
- Make sure motor, auditory, and semantic memory are all equally strong.
- Practice playing from memory while thinking about expression, sound, phrasing and not technique or specific notes.
- Video record yourself playing from memory often.
- Perform from memory for others often before a concert/audition.

Performing from memory can be an exhilarating, freeing experience when you aren't tied to looking at the page in front of you. Hopefully the suggestions in this article will give you greater courage and confidence to perform without aid of the printed page.

Molly Gebrian currently teaches viola at the University of Wisconsin-Eau Claire. She holds degrees in both viola performance and neuroscience and is a frequent presenter and writer on topics having to do with music and the brain.

Notes

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