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Performing from Memory

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Abstract and Keywords

Performing reliably from memory requires two different types of memory organization: associative chains and content addresses. Associative chains develop spontaneously during practice, but have the disadvantage that when something goes wrong and the chain breaks, the performer must start over from the beginning. To avoid such embarrassment, experienced performers develop the ability to start from multiple locations in a piece. The hierarchical organization provided by the musical structure supplies addresses, making memory content addressable; for example, thinking "second theme" brings the music to mind. To develop content addressable access, the musician must attend to particular features of the music repeatedly during practice until they become performance cues. These are thoughts, like "second theme," "listen," "excitement," that have been prepared during practice and come to mind spontaneously and reliably during performance, guiding the musician and providing places where playing can resume if things go wrong.

Keywords: memory, performance, performance cues, memory organization, content addressable access

Introduction

What is the difference between "learning" a new piece of music and "memorizing" it? Both involve memory, but of different kinds. The memories that develop spontaneously while learning a new piece take the form of associative chains in which each passage cues the memory of what comes next. Associative chains have a major weakness: to reach any link in the chain you have to start at the beginning. For a musician, this becomes a problem when something goes wrong in performance. Besides the embarrassment of starting over, there is the agony of wondering whether memory will fail again in the same place.

Deliberate memorization transforms the motor and auditory chains created while learning the piece by making them content addressable. A memory is content addressable if you can ask yourself, for example, "How does the third repetition of the main theme go?," and the music comes to mind. In other words, it can be located directly by thinking of the relevant location in the piece. In a memorized performance, content addressable memory provides a safety net that permits recovery in case the associative chain breaks and the performance is disrupted.

Associative chains and content addresses are two different ways of accessing memory and they have different properties (Farrell, 2012). Memories accessed by content address are more likely to be explicit (conscious) and easier to express in words. Associative chains are more likely to be implicit (unconscious) and to involve procedural (motor-based) knowledge that cannot be readily expressed in words. To memorize music for performance, the musician must smoothly integrate the two kinds of memory.

Musicians distinguish the two types by referring to "learning" and "memorizing," but they also use the term "memory" to refer to both. There is potential for confusion here. For example, some musicians say that they do not memorize, that it is “something that just happens” (André-Michel Schub), “a subconscious process” (Harold Bauer), “like breathing” (Jorge Bolet). Others believe that “every performer has to work at memorizing” (John Browning) and suffer from “that terror of forgetting” (Janina Fialkowska; all cited in Chaffin, Imreh and Crawford, 2002, ch. 3). Are they talking about the same thing?

The important question for the performer is whether memory will be reliable on stage. What happens if something goes wrong? If the memory is in the form of an associative chain, then the only recourse is to start again at the beginning of the chain. This kind of memory failure is an unfortunate staple of student recitals. Students often assume that because they can get through a piece without the score in the studio, they can do the same on stage. They do not appreciate that the associative chain is not the same thing as a reliable, content addressable memory.

Experienced performers know better. Memory failures are inevitable. A performer may go for years without one, but eventually it will happen. The important thing is to recover gracefully. Experienced performers do not stop and go back to the beginning. They go on. They have a mental map of the piece that allows them to keep track of where they are as the performance unfolds. The map provides landmarks where they can restart the performance if necessary (Chaffin et al., 2002, ch. 9). When something goes wrong, the expert jumps to the next landmark and the performance continues. Most of the time, the audience is not even aware of the mistake. Landmarks provide a safety net.

Our account builds on the view of memory described by Bob Snyder in this volume (also Ginsborg, 2004,), and draws on research on oral traditions and expert memory. First, we will describe how musical material, such as folk songs, can be passed down, more or less unchanged, across centuries without the benefit of written records. Subsequently, we will explain how experts are able to perform extraordinary feats of memory, such as the young Mozart writing out Allegri’s *Miserere* from memory. Careful study suggests that such feats are not the product of a special talent for memorization. Instead, they are the predictable result of a deep familiarity with musical styles and conventions combined with effective strategies for making memories content addressable. Finally, we combine these two areas of research to explain how experienced performers memorize, as opposed to simply learn, a new piece.

Associative Chaining

Music performance relies heavily on associative chaining: what you are playing reminds you of what comes next. In this respect, music is similar to many other kinds of ordered sequences that people regularly encounter, such as nursery rhymes and poems. Memorization is helped by the fact that what comes next is heavily constrained by what precedes it (Rubin, 1995, 2006). For example,

> There was a young man of Japan,
> Whose limericks never would ____.

One need not have heard this limerick before to know that the missing word is “scan.” The possibilities are constrained by syntax, semantics, rhyme, and rhythm. We know that the second line must rhyme with the first because we recognize it as a limerick. Our previous experience of limericks is stored in long-term memory in the form of a *memory schema* that tells us what to expect. Anticipation of this sort is a normal product of the way that memory functions.

The Role of Schemas

Contrary to popular belief, memory is not a vast storehouse containing exact records (Brewer, 1987). Memories for specific events (episodic memories) are reconstructed at each remembering on the basis of schematic (semantic) knowledge representing generic memories (Tulving, 1972). Schemas allow us economically to recall our past in enormous detail, but this ability has a price. When we take the trouble to check, many of the details turn out to be wrong. The same schematic frameworks that allow us to remember are also a source of distortion. We remember the gist, and fill in the details, without distinguishing what we have accurately remembered from what we have simply assumed (Brewer and Treyens, 1981).

Given the fallibility of memory, musicians’ routine reliance on rote memory seems remarkable. How is accurate recall possible if memory for a piece must be reconstructed from generic musical schemas each time it is played? We would expect performances to be full of mistakes as the musician replaces the exact notes provided by the composer with the musical gist based on generic knowledge of harmonic, melodic, metric, and rhythmic patterns.

The answer comes from studies of how memory functions in oral traditions (Rubin, 1995, 2006). In non-literate cultures, oral traditions such as ballads, epic poems, and religious enactments often remain stable across centuries. For example, in North Carolina, ballads handed down through oral tradition to singers in modern times are directly traceable to European ballads of the Middle Ages. How were they were transmitted, more or less verbatim, across so many generations? Like those of everyone else, the memories of bards, minstrels, and storytellers are reconstructed at each performance. Their performances do vary, but they are sufficiently consistent that the distortion is minimal, even across generations. This surprising level of accuracy is the product of *multiple constraints*. Our example of the limerick illustrates how multiple constraints on rhyme, rhythm, alliteration, and content limit the possibilities for memory errors. Constraints of this sort are found in every oral tradition that has been studied.

Music is constrained by genre and style, melody and harmony, meter and rhythm, and by repetition, which is much more pronounced in music than in language (Huron, 2006, pp. 229–231). All these constraints combine to make the task of memory reconstruction easier. This is why memorization is so much easier for experienced musicians than for novices (Ginsborg and Sloboda, 2007; Williamon and Valentine, 2002): experts have more constraints. This is also why it is quicker to memorize songs by learning words and music together rather than separately (Ginsborg and Sloboda, 2007): together there are more constraints.

Multiple Memory Systems

Like other materials transmitted through oral tradition, music is recalled as part of a performance. Performance calls on the many different cognitive and bodily systems involved in action, each of which lays down its own memory traces. Each type of memory provides retrieval cues and constrains memory reconstruction, making memory for performance more robust than memory for text (Rubin, 1995, 2006). We focus on those memory systems most relevant to musical performance: auditory, motor, structural, emotional, visual, and linguistic.

Auditory Memory

The history of Western music is full of stories of musicians who were able to hear entire works in their heads (Deutsch and Pierce, 1992). Everyone has the ability to “hear” sounds in their heads (Hubbard, 2010), including melodies (Halpern, 1992; Reisberg, 2001, ch. 11). Neuropsychological studies suggest that, like other forms of memory, auditory memories are localized in their own area of the brain (e.g., Fornazzari, Nadkarni and Miranda, 2006). Auditory memory appears to contain information about both pitch contour (relative pitch) and pitch category (absolute pitch), since people tend to recall music in the same key as the original (Dowling, 1978; Halpern, 1989).

In performance, auditory memory lets musicians know that they are on track and activates memory for what comes next (Finney and Palmer, 2003). Developing auditory schemas for standard rhythmic, melodic, harmonic, and stylistic patterns narrows the range of possibilities for recall, enabling musicians to remember music better than non-musicians (Halpern and Bower, 1982). Developing this ability is a normal part of advanced musical training (Gordon, 1999). Sight singing and training in notational audiation help to develop the musical schemas that allow musicians to perform on their instrument with or without a score (Brodsky et al, 2008; Woody, 2012).

Motor Memory

Musicians are referring to motor memory when they talk about memory as being “in the hands.” Perhaps the most important feature of motor memory for musicians is that it is implicit (unconscious). Musicians know that they can play a particular piece (declarative knowledge), but the knowledge of how to play can only be exhibited by actually playing (procedural knowledge). This can be a source of anxiety and lead to over-practice. Playing seems to be the only way to reassure oneself that memory for a piece is intact. Mental practice provides an alternative but requires explicit memory. To make motor memory explicit, actions must be recoded in propositional form so that they can be rehearsed in working memory as a thought of the general form: “Next, do this.” This kind of mental instruction is a form of linguistic memory, discussed below.

Motor memory necessarily involves associative chaining; each action cues the next. This is what makes motor memories implicit: to be accessed, they must be performed. Adding content addressable access makes it possible to jump around in a piece, skipping backwards or forwards. What is required is a retrieval cue—a thought in working memory that activates the motor memory, restarting the associative chain at a new location. Chaffin et al. (2002) introduced the term *performance cue* to refer to the use of this kind of cue in music performance. When experts memorize for performance, much of the work is directed at setting up performance cues (see below).

Structural Memory

Memories for events are organized into narratives based on the goals of the actors involved (Brewer, 1980, p. 223). In music, the musical structure provides a similar kind of hierarchical organization, dividing a piece into sections and subsections based on melody, harmony, and meter. Hierarchical organizations of this sort provide useful frameworks for generating content addresses: for example, third movement, second theme, third bar. Of course, it requires considerable musical understanding to generate addresses of this sort. One reason that people have trouble memorizing music is because they do not have a good understanding of the musical structure. Awareness of structure develops slowly with musical training (Williamon and Valentine, 2002) and may be lacking, even in experienced musicians (Snyder, this volume).

When experienced musicians prepare a new piece of music, they identify its structural properties and use them to organize both their practice and their memories (Chaffin and Imreh, 2002; Chaffin, Lisboa, Logan and Begosh, 2010; Hallam, 1995; Williamon and Valentine, 2002). For example, a musician may think to herself as she plays through a piece for the first time, “That’s the second theme” (Chaffin, 2007). If the structure is obscure, an experienced musician takes the time to figure it out, even if doing so requires weeks of work (Chaffin, Gerling, Demos and Melms, 2013). Without a clear understanding of the structure, there is no mental map, and no content addressable memory.

Emotional Memory

Emotional memories[1] of all kinds are remembered better than non-emotional memories (Bower, 1981; Talmi, Schimmack, Paterson and Moscovitch, 2007), and this is true for both music listening (Schulkind, Hennis and Rubin, 1999) and music performance (Chaffin, 2011). The positive effects of emotion are disrupted by damage to neural areas involved in emotion (Greenberg and Rubin, 2003). We can see the contribution of emotion to performance memory when researchers ask musicians to perform without expression in laboratory studies; the musicians often have difficulty playing. We surmise that playing without expression reduces emotional cues that normally contribute to the retrieval of music from memory (e.g., Demos, 2013).

Visual Memory

There are large individual differences between musicians in their subjective experience of visual memory. Some musicians report having “photographic” memories, while others say that their visual memories are poor or unhelpful. For example, Myra Hess described how she could “see” and “read” the printed page when playing from memory, whereas Alfred Brendel reported that his memory was “not visual at all” (Chaffin et al., 2002, pp. 37–41). These reports may reflect real differences in the detailed information available in visual memory (Reisberg, 2001, ch. 11). However, reports of visual images can be misleading in two ways. First, mental images are not pictures, i.e., objective depictions of reality. Images are interpretations. To discover whether she had misread a note, Myra Hess could not inspect her mental image of the score; she had to look at the real thing. Second, people who report having no visual memory still have spatial memories. They know the location of notes on the page and, as a result, might well have the same trouble using a different edition of a score as a person who has vivid mental images.

Linguistic Memory

The mental instructions that experienced performers use to remind themselves what to do at key points in a performance are a form of linguistic memory (Chaffin et al., 2002). These instructions do not necessarily involve words, but they do have a language-like “subject-predicate” (propositional) form, often pointing to other, modality-specific memories: motor, auditory, visual, and emotional (Binder and Desai, 2011), for example, Hold back” (pointing to motor memory) or “Now, like this” (pointing to auditory memory). Their propositional form allows them to be rehearsed in working memory, from where they can direct other mental processes and implement plans and strategies (Baars, 1988, pp. 99–104; Reisberg, 1992, p. viii; Rubin, 2006). "Internal speech" can be used for mental rehearsal and to help recover if the associative chain breaks during a performance from memory.

Content Addressable Memory

Associative chaining works well so long as the chain is intact. If the performance stops, however, the chain is broken. The performer can only go back to the beginning and start over. To avoid such ignominy, experienced performers provides themselves with other options: they prepare multiple starting points.

When you want to sing happy birthday, you simply think, "Happy Birthday," and start singing. The verbal label acts as a retrieval cue for the start of the song and the rest is then cued by associative chaining. Now imagine that you want to start at the last line. Most of us cannot do this immediately. We have to start at the beginning and run through. Once we have the last line in working memory, however, we can easily set up a new starting point by thinking, "Start of the last line" as we sing. A few repetitions to strengthen the associative link between the new cue and singing the last line and we have a new starting point. Any time, we want to start at the last line, we can now simply think, "Start of the last line" and start singing. We have set up a new performance cue, making this place in the music content addressable (Chaffin, 2011). Simply thinking of the cue now activates the memories needed to start singing. The performance cue provides flexibility and control. You can now think of the passage at any time, without running through the whole piece from the beginning.

We will focus on two aspects of this strategy. First, when applied to a long piece of music, the strategy of creating multiple starting points has many similarities with how experts memorize in other domains that have nothing to do with music. We will describe these similarities in the section "Expert Memory." Second, there is a risk involved in setting up additional starting points. Thinking about what you are doing can interfere with skilled performance, a phenomenon known as choking (Beilock and Carr, 2001). We will describe how experienced musicians avoid this problem in the section on "Performance Cues".

Expert Memory

Experts in any domain memorize with a facility that often seems superhuman (Chase and Simon, 1973; Gobet and Simon, 1996). Musicians are no exception; as we have already noted, their biographies are full of tales of amazing memory feats. These feats are made possible by the use highly practiced retrieval strategies (Chase and Ericsson, 1982; Ericsson and Kintsch, 1995). Our understanding of expert memory is based on the study of memory for domains such as chessboards, digit strings, and dinner orders that are very different from music performance. Motor memory probably plays a minor role in recalling the position of pieces on a chessboard or the orders of a table full of customers in a restaurant. Despite the differences, the principles of expert memory established in these domains apply to music performance because experienced musicians also rely on structural and linguistic memory to provide them with content addressable access.

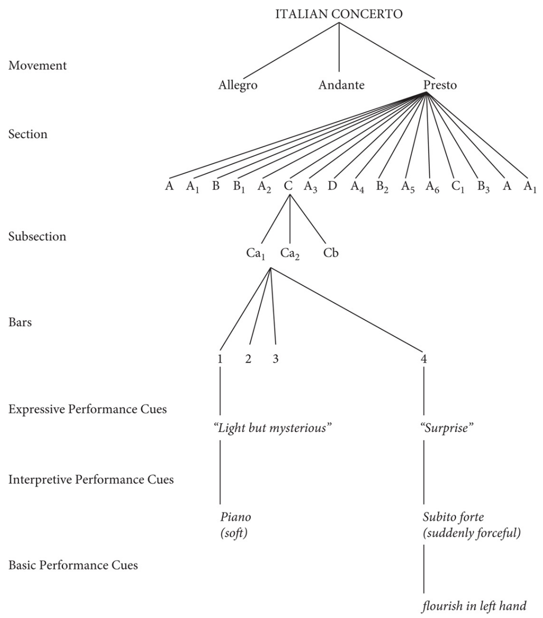

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Figure 1. Hypothetical hierarchical retrieval scheme "unpacked" for Section C of the Presto from the *Italian Concerto* by J.S. Bach. Main themes (sections) are represented by capital letters. Section C is "unpacked" into subsections (Ca1, Ca2, Cb). Subsection Ca1 is further "unpacked" into its performance cues

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The feats of expert memorists can be explained in terms of three principles: meaningful encoding of novel material, use of a well learned retrieval structure, and extended practice to decrease the time needed for retrieval from long-term memory (Ericsson and Kintsch, 1995). The same three principles apply to expert music performance (Chaffin and Imreh, 2002; Krampe and Ericsson, 1996). First, experts' knowledge of their domain of expertise allows them to make use of schematic knowledge already stored in memory to organize information into larger chunks (Brewer, 1987). For a musician, these include familiar patterns like chords, scales, and arpeggios, whose practice forms an important part of every musician's training (Halpern and Bower, 1982). Second, expert memory in any domain requires a retrieval scheme to organize the cues that provide access to the chunks of information in long-term memory (Ericsson and Charness, 1994). For a musician, the formal structure of the music provides a ready-made hierarchical organization to serve as a retrieval scheme (Williamon and Valentine, 2002). For example, Figure 1 shows how the hierarchical organization of the Italian Concerto (Presto) by J.S. Bach into movements, sections, subsections, and bars was used by a pianist to organize her memory for the piece (Chaffin et al., 2002). The third principle of expert memory is that prolonged practice is needed in order to use a retrieval scheme like the one in Figure 1 at rates that are rapid enough to be useful (Ericsson and Kintsch, 1995). For the musician, this involves practicing memory retrieval until it is fast enough to keep pace with the performance.

Rapid memory retrieval is important in music performance to prevent the hands from "running away" as the retrieval of procedural knowledge by associative chaining outpaces the slower, content-addressable retrieval of declarative knowledge. The smooth integration of the two systems creates "long-term working memory" (Ericsson and Kintsch, 1995). Practice is needed so that the performance cue for what comes next arrives in working memory at just the right moment, before the corresponding motor sequences, but not so soon that it distracts from the execution of the preceding passage and causes "choking."

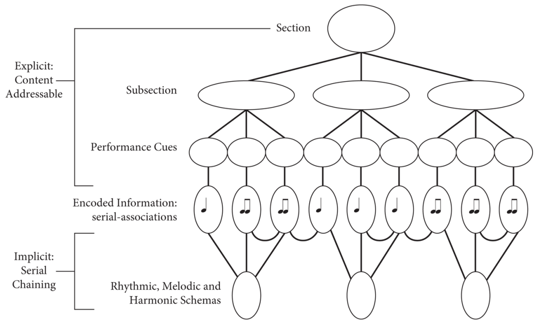

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Figure 2. Model of episodic memory for music performance showing separate retrieval organizations for access by content address and by serial chaining.

Adapted from K.A. Ericsson and W. Kintsch, Long-term working memory, *Psychological Review*, *102* (2), 211–245, http://dx.doi.org/10.1037 Copyright © 1995, The American Psychological Association.

The interplay of the two retrieval systems is illustrated in Figure 2, which shows the two routes by which memory for a piece of music can be retrieved. At the bottom of the figure are the serial associations set up while learning to play the piece. These associations, based on schemas for rhythm, meter, harmony, and melody, directly link each passage with the next. Each passage is cued by the preceding passage. Direct, content addressable access is provided by a second retrieval system, shown at the top of the figure. Here, a hierarchical retrieval organization, similar to that in Figure 1, provides direct access to any section of the piece. Performance cues embedded in this organization provide possible "starting points" in case things go wrong in performance.

Performance Cues

One of the main challenges in memorizing for performance is to integrate the two retrieval systems. As one pianist put it in talking about learning the Italian Concerto (Presto) by J.S. Bach:

> My fingers were playing the notes just fine. The practice I needed was in my head. I had to learn to keep track of where I was. It was a matter of learning exactly what I needed to be thinking of as I played, and at exactly what point so that as I approached a switching point I would automatically think about where I was, and which way the switch would go.
>
> (Chaffin et al., 2002, p. 224)

The pianist was talking about performance cues.

Performance cues are landmarks in the mental map of a piece that an experienced musician attends to during performance. Because they can be accessed both by serial cueing and directly by address, they provide a safety net in case serial cueing breaks down. Careful preparation of performance cues makes it possible for soloists reliably to perform challenging works from memory on the concert stage. By repeatedly paying attention to performance cues during practice, the musician ensures that they become an integral part of the performance, coming to mind effortlessly as the music unfolds. The performer remains mindful of these aspects of the performance while allowing others to occur automatically (Chaffin and Logan, 2006). In any particular performance, musicians normally attend to only a subset of the performance cues they have prepared, using them strategically in response to the needs of the moment (Ginsborg, Chaffin and Demos, 2012). When things go smoothly, performance cues are a source of spontaneity and variation in highly polished performances (Chaffin, Lemieux and Chen, 2007; Ginsborg et al., 2012). When things go wrong, they provide places at which the soloist can recover and go on.

Performance cues point to different types of memory according to which aspect of the music they address: structure, expression, interpretation, or basic technique (Chaffin et al., 2002; Chaffin, Lisboa, Logan and Begosh, 2010; Ginsborg, Chaffin and Nicholson, 2006). Performance cues are content addressable through their location in the hierarchical organization of the piece (see Figure 1). In learning a new piece, the musician moves up and down the hierarchy, attending to each level of organization and each type of cue in turn (Williamon, Valentine and Valentine, 2002). Like experts in other fields, who approach a new problem by looking at the "big picture," experienced musicians approach the task of learning a new piece by first understanding its structure and expressive shape (Chaffin, Imreh, Lemieux and Chen, 2003; Lisboa, Chaffin and Logan, 2012). Beyond this commonality, the order in which different types of performance cue are practiced depends on the individual, piece, and situation (Chaffin, 2011; Chaffin et al., 2013). What experienced performers have in common is that they practice performance cues and so have a safety net for times when associative cueing fails.

Conclusion

Though it has a long history in Western classical music, playing from memory is often a source of anxiety for performers. Lazar Berman reported, "Every time I play in front of an audience, it is a very important and difficult affair, both physically and spiritually. I am never sure that it is going to end well" (Chaffin et al., 2002, ch. 3). Anton Rubinstein wrote that fear of memory failure "inflicted upon me tortures only to be compared with those of the Inquisition" (Rubinstein, 1969, p. 18).

Given the costs involved in playing from memory and its long tradition, stretching back 175 years, it might be expected that musicians would have developed a systematic understanding of the problems involved. This has not happened (Aiello and Williamon, 2004). Individual musicians know a great deal about strategies for memorization (Hallam, 1995, 1997), but this knowledge is conveyed from teacher to student through an apprenticeship system that makes it unavailable for systematic analysis. Memorization is viewed as an individual and mysterious process. It is up to each person to find their own method (Ginsborg, 2002). This is regrettable and unnecessary (Lisboa, Chaffin and Demos, 2015). There is no reason to think that musical memory varies any more from one person to another than any other trait or capacity. Beneath a superficial diversity, the cognitive and neurological systems involved in memory are common to all human beings. In this chapter we have described those aspects that are most relevant to performing music from memory.

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Notes:

([1]) Our use of this term is an oversimplification. Emotion is a complex and varied phenomenon that draws on multiple neural systems (Rubin, 2006).

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