CHAPTER 33

Performing from memory

Roger Chaffin, Topher R. Logan and Kristen T. Begosh

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. Deliberate memorization transforms the motor and auditory chains, making them *content addressable*. A memory is content addressable if you can ask yourself, e.g., 'How does the third repetition of the main theme go?', and the music comes to mind. 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. Content-addressable memories avoid this problem. They 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-addressable memories are learned in different ways and have different properties. Content-addressable memories are more likely to be explicit (conscious) and to involve declarative (language-based) knowledge *that* such-and-such is the case, whereas associative chains are more likely to be implicit (unconscious) and to involve procedural (motor-based) knowledge of *how* to do something. To memorize a piece of music for performance, the musician must smoothly integrate the two kinds of memory.

English has only the one term 'memory' to refer to these two very different mental processes. In everyday talk, musicians make the distinction by referring to 'learning' and 'memorizing'. There is the potential for confusion here. For example, how should we understand musicians who say that they do not memorize, for whom memorization is 'something that just happens' (André-Michel Schub), 'a subconscious process' (Harold Bauer), that is 'very simple' (Walter Gieseking), 'like breathing' (Jorge Bolet); how should we understand Jorge Bolet, when he says that he memorized Liszt's *Mephisto Waltz* in 75 minutes (Chaffin *et al.* 2002, Chapter 3)?

For the musician, the relevant question is whether memory will be reliable on stage. Jorge Bolet probably did not mean that he was ready to go on stage and perform. Professional performers may sometimes find themselves in the position of having to perform at short notice, but they do not normally choose to. It is risky. 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 catastrophic memory failure is an unfortunate staple of student recitals. Students often make the mistake of assuming that because they can get through a piece without the score in the studio, they can do the same in live performance. They do not appreciate that the associative chain is just the first step; much more work is needed to create a reliable, content-addressable memory.

Experienced performers know better; they give themselves a safety net. Memory failures are inevitable in live performance. A performer may go for years without a problem but, with enough performances, 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, Chapter 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 that anything went wrong. Memorization is the creation of this safety net.

Our account of memory for performance builds on the standard view of memory described by Bob Snyder in Chapter 10 of this volume (also Ginsborg 2004). We focus on the role of serial chaining and content addressability. Two areas of the episodic memory literature are particularly relevant to our discussion: oral traditions and expert memory. In oral traditions, materials such as children's rhymes and folk songs are handed down from one generation to another without the benefit of written records, often for hundreds of years. We will draw on David Rubin's (1995, 2006) analysis of this phenomenon and on his *basic system theory of episodic memory* to describe the role of different types of memory (auditory, motor, visual, emotional, structural, and linguistic) in associative chaining.

The second area of psychological research that we will draw on is the study of expert memory. The history of music is filled with examples of extraordinary feats of memory and these are often exhibited as evidence that the musician in question possessed some special gift or talent. For example, the young Mozart's writing out of Allegri's *Miserere* from memory was seen, at the time and ever since, as evidence of his genius (Chaffin *et al.* 2002, p. 66). The conclusion of careful study by psychologists is that such feats are *not* the product of a special talent for memorization but are the entirely predictable result of years of training and the effective use of retrieval schemes (Ericsson and Charness 1994). Expert memorists develop retrieval strategies to make their memories content addressable so that they can find the information they need when they need it (Ericsson and Kintsch 1995). We will use Anders Ericsson's theory of expert memory 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, memory for music is similar to memory for rhymes, songs, and poems. In each case, the task of memorization is made easier 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 ____.

The possibilities for the next word in this little verse are constrained by syntax to verbs, by semantics to verbs that can take 'limericks' as agent, and by rhyme to words that end in '__an'. These multiple constraints narrow the possibilities. One does not have to have heard this limerick before to know that the missing word is 'scan'.

The role of schemas[1]

How do we know that the second line must rhyme with the first? We recognize it as a limerick. Even if the word 'limerick' were not explicitly mentioned in the second line, we would recognize the characteristic formulaic opening and 'Te dee-ya, te dee-ya, te-dum' rhythm. Rapid recognition of this sort is a normal feature of memory: it is the same when we recognize a strawberry, a rain storm, or a birthday party. Information in long-term memory is represented in the form of *schemas* that summarize our previous experience and tell us what to expect. The schema for

[1] The Latin root of 'schema' dictates a plural form 'schema' or 'schemata'. We prefer the more regular, colloquial form 'schemas'. All three forms are in common use in the psychological literature.

limericks tells us that the second line will rhyme with the first. Similarly, schemas tell us to eat strawberries, use umbrellas when it rains, and give presents at birthday parties.

Contrary to popular belief, memory is not a vast storehouse containing exact records of a myriad of original events (Mandler 1984). Memories for specific events (episodic memories) are *reconstructed* at each remembering on the basis of schematic (semantic) knowledge representing generic memories. Schemas allow us to economically 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, systematically misremembering in the process.

Given the general 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, indicating that memories for their performance have been transmitted, more or less verbatim, from one generation to the next across many years. How is this done? Like everyone else, the memories of bards, minstrels, and storytellers are reconstructed at each performance (Rubin 1995, 2006). Their performances *do* vary, but they are sufficiently consistent that the distortion is minimal, even across generations. This surprising level of accuracy is a product of *multiple constraints*. In every oral tradition studied, the material follows strict formal constraints on rhyme, rhythm, and alliteration. Our example of the limerick illustrates how these constraints operate. The multiple constraints of grammar, meaning, metre and rhyme reduce the possibilities available.

In music, similar constraints are provided by melody, harmony, metre, and rhythm. In addition, repetition is normally much more pronounced in music than in language and provides additional local constraints (Huron 2006, p. 229–231). All of these constraints combine to make the task of memory reconstruction easier. Knowing how different composers use the various conventions of each musical genre makes constraints more specific, and so memorization is easier for experts than for novices (Williamon and Valentine 2002). In song, the constraints of the musical and literary forms combine, making memorization easier when words or music are learned together rather than separately (Ginsborg and Sloboda 2007).

Multiple memory systems

Another feature that music shares with the materials transmitted in oral traditions is that it 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, subject to its own schemas. These provide multiple retrieval cues, making memory for performance more robust than memory for text (Rubin 1995, 2006). On the basis of cognitive and neurological evidence, Rubin (2006) has proposed a model of memory in which multiple memory systems contribute to episodic memories. We will restrict our description to those systems most relevant to musical performance: auditory, motor, visual, emotional, narrative, and linguistic memory. A memorized performance is generated through the interaction of the information available in each system. For example, musicians find it easier to play a piece of music they have memorized than to write it out because playing provides memory cues from the motor system that are absent when writing out the score (Chaffin and Logan 2006). Just as in the limerick example, the multiple retrieval cues from the different systems interact to reduce the range of possibilities.

Auditory memory

The history of Western music is replete with stories of musicians who were able to hear entire works in their heads (Deutsch and Pierce 1992). Psychological studies confirm this ability in people with or without musical training, and have begun to specify the form in which the auditory information is stored (Halpern 1992). These studies confirm that people can 'hear' a melody in their heads, usually without accompanying imagery from other modalities, suggesting that the ability is based on an independent auditory memory (Reisberg 2001, Chapter 11). Neuropsychological studies provide further confirmation of the existence of a separate auditory subsystem (e.g. Fornazzari *et al.* 2006). In performance, auditory memory tells the musician what comes next, providing cues to elicit the music from memory, while also letting the musician know that things are on track (Finney and Palmer 2003).

We demonstrated one important way that auditory memory helps constrain recall when we showed how the rhythmic and rhyming schema for limericks narrow the range of possibilities for recall. In a similar vein, Rubin (2006) argued that the organization of ballads into stanzas with invariant metric and rhyming schemas has been largely responsible for the preservation of an oral tradition in North Carolina that is directly traceable to European ballads of the Middle Ages. In similar ways, schemas for standard rhythmic, melodic and harmonic patterns allow musicians to remember music better than non-musicians (Halpern and Bower 1982). Auditory memory appears to contain information about both pitch contour (relative pitch) as well as pitch category (absolute pitch), since people can sometimes recall music in the same key as the original (Dowling 1978; Halpern 1989).[2]

Motor memory

Motor memory allows actions to be executed automatically by providing kinaesthetic memory of the sensory feedback from joints, muscles, and touch receptors. Although motor skills have been studied since the earliest days of experimental psychology (Adams 1987), the contribution of the motor system to memory was neglected by early cognitive theories of memory, entering mainstream cognitive theorizing only with the distinction between procedural (motor) and declarative (conceptual) memory (Anderson 1978; Squire 1987). More recently, the discovery of 'mirror neurons' in the motor system that respond to seeing the corresponding action performed by another (Rizzolatti and Craighero 2004) has reaffirmed earlier claims that the motor and sensory systems are intimately linked (Liberman and Mattingly 1985). The motor system is still largely treated as a completely separate system (Rosenbaum 2005), however, and the study of its contribution to memory is still in its infancy, under the rubric of 'embodied cognition' (Glenberg 1997).

Musicians talk about motor 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 is a source of anxiety, and may 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 mental instruction is a form of *linguistic memory*, discussed below.

Motor memory provides the clearest examples of associative chaining in memory; each action in the series cues the next. This is what makes motor memories implicit: to be accessed, they must be performed. Actions can, of course, be cued in other ways. People stand up for national anthems, shake hands when introduced, and remember to stop at the grocery store on the way home from work. This last example is different from the others, because the action is directed by a cue that we provide for ourselves. The cue is a thought in working memory, e.g., 'Take this exit'. This is the same kind of self-cuing that mental rehearsal possible. Chaffin, Imreh & Crawford (2002) introduced the term *performance cues* to refer to the use of this kind of cue in music performance. Setting up performance cues is the main work involved in memorizing for performance and is described below in the sections on *expert memory* and *performance cues.*

[2] Remembering pitch contour requires the use of spatial imagery which Rubin (2006) identifies as a separate basic system.

Visual memory

Visual memory of the score is used mainly in the early stages of memorizing, while visual memory of the hands on the instrument becomes more important in the later stages. The role of visual memory for the score is evident in the difficulty that some musicians experience when working with a different edition of a score from the one they used to initially learn a piece (e.g. Chaffin *et al.* 2002, p. 37). A new score is difficult to work with because the visual information it provides is different from the musician's visual memory. It is common to remember the location of a passage on the page, a form of spatial imagery. Student musicians frequently use the spatial organization of music by pages rather than the formal structure of the piece to organize their practice (Williamon and Valentine 2000).

As in the general population, 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 probably reflect real differences in the detailed information available in visual memory (Reisberg 2001, Chapter 11). Reports of visual images are misleading, however, in two ways. First, mental images are *not* pictures. Images are not neutral, objective depictions of reality but are organized interpretations that reflect the way that the original was understood. To discover whether you misread a note you cannot inspect your mental image of the score, you have to go back and look at the real thing. Second, people who report having no visual memory still have spatial memories which are stored in a separate system. While spatial memory does not provide a vivid subjective experience, it does provide information about the location of notes on the page.[3] So a person could experience no visual imagery but still be disrupted by using a different edition of a score.

Emotional memory

Memories for emotional events are formed more easily and are less likely to be forgotten than non-emotional memories (Bower 1981; Talmi *et al.* 2007). This is as true for music as any other material (Schulkind *et al.* 1999). The positive effects of emotion on memory are disrupted by damage to neural areas involved in emotion (Greenberg and Rubin 2003). Together, these findings are the basis for identifying emotional memory as a separate system.[4] It seems clear that the performer's visceral response to the music contributes to musical memory. We have observed that musicians find it difficult to play from memory when asked to perform without expression and surmise that playing without expression eliminates emotional cues that normally contribute to the retrieval of the music from memory.

Structural memory

We suggest that structural memory is the musical equivalent of Rubin's *narrative memory*: memory for the overall sequential organization and goal structure of a story or biography. Memories for events are organized by schemas that connect temporal series of discrete actions through narrative structures based on the goals of the actors involved (Mandler 1984). Although often expressed in language, narrative structure can be expressed in a variety of forms including pictures, cartoons, silent films, dreams, dance, and mime (Rubin 2006). In the Western classical tradition, the same kind of narrative structure is responsible for the hierarchical organization of a piece into sections and subsections based on melodic, harmonic, and metrical structures. In preparing a piece of music, experienced musicians analyse these structural properties and use them to organize both their practice and their memories (Chaffin and Imreh 1997,

[3] We have not followed Rubin (2006) in singling out spatial imagery as a separate form of memory because in music performance it appears to operate across modalities, binding together representations in the auditory, motor, and visual systems

[4] This is an oversimplification since emotion is a complex and varied phenomenon that draws on multiple neural systems (Rubin 2006).

2002; Chaffin *et al.* 2002; Hallam 1995; Williamon and Valentine 2002).

In 'programme' music, narrative organization is explicitly applied to music. Despite the resistance of critics to providing a storyline for every piece of music, the ease with which music lends itself to this kind of treatment suggests that musical and narrative structure share common roots. We suggest that they stem from the same cognitive system; musical form and the storyline of a musical programme are both manifestations the underlying ability to identify large-scale structural relations between events.

An important difference between narrative and musical structure is that the former seems to be easier to perceive. Even young children are sensitive to narrative structure (Nelson and Fivush 2004), whereas sensitivity to musical structure develops slowly with musical training (Williamon and Valentine 2002) and is not always found, even with experienced musicians (Chapter 10 this volume, pp 113–115). The difference may be due to the fact that in our culture people generally have a lot more experience telling stories than they do playing music.

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).[5] These instructions do not necessarily involve words. They are stored in an abstract 'subject-predicate' (propositional) form that usually points to other modalities (motor, auditory, visual, and emotional memories). However, their propositional form means that they can normally be glossed in words, e.g., 'Hold back' or 'Now, like this' (Englekamp 2001).

An important characteristic of linguistic memories is that they can be rehearsed in working memory, where they can serve to direct other mental processes. When the activity of other cognitive systems is re-described in language, the inner speech that results provides a means of mental control that can be used to implement plans and strategies (Reisberg 1992, p. viii; Rubin 2006).[6] Rehearsing a mental instruction in working memory broadcasts it throughout the nervous system, automatically activating other systems and coordinating their activity (Barrs 1988).[7] As we noted above, this ability can be used for mental rehearsal or to recover if the associative chain of a memorized performance breaks.

Content-addressable memory

Associative chaining works well so long as the chain is intact. If the performance stops, however, the chain is broken, and then memory failure is complete and catastrophic. The performer can only go back to the beginning and start over. To avoid such ignominy, experienced performers prepare a safety net that provides 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 *et al.* 2002). Simply thinking of the cue now activates the memories needed to start singing.

[5] The first author has previously referred to both linguistic and structural memory as 'conceptual' or 'declarative' memory (e.g., Chaffin *et al.* 2002; Chaffin and Imreh, 2002). The present terminology represents a refinement of that classification.

[6] The important role of inner speech in mental control has been noted by many psychologists including Pavlov, Watson, Vygotsky, and Piaget.

[7] The process of directing and monitoring our own mental operations in this way may be responsible for uniquely human qualities of conscious experience (Dennett 1991).

The performance cue lacks the multidimensional richness of the associative chain, where the next link was cued by sound, action, and emotion. What it lacks in richness, it makes up for in flexibility. 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 next section. 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 seems superhuman (Gobet and Simon 1996). Musicians are no exception; as we have already noted, their biographies are full of tales of amazing memory feats. The abilities of other expert memorists have been attributed to the use of highly practiced retrieval strategies by skilled memory theory (Chase and Ericsson 1982) and its extension, long-term working memory theory (Ericsson and Kintsch 1995). These theories are based on the study of domains such as chess boards (Chase and Simon 1973), digit strings (Thompson *et al.* 1993), and dinner orders (Ericsson and Oliver 1989) that are very different from music performance: structural and linguistic memory are primary and associative chaining of motor and auditory memories play minor roles. 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 a safety net in case the chain of motor and auditory memories breaks (Chaffin and Logan 2006).

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 *et al.* 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 (Tulving 1962). 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 Oliver 1989). For a musician, the formal structure of the music conveniently provides a ready-made hierarchical organization to serve as a retrieval scheme. For example, Figure 33.1 shows how the hierarchical organization of JS Bach's Italian Concerto (Presto) 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 required to bring the speed of operation of a memory retrieval scheme like the one in Figure 33.1 up to the speed needed to guide behaviour (Ericsson and Kintsch 1995). For the musician, this involves practising memory retrieval until it is rapid and reliable 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 far in advance as to distract from the execution of the preceding passage and cause 'choking'.

The interplay of the two retrieval systems is illustrated in Figure 33.2. The figures shows the two routes by which memory for a piece of music

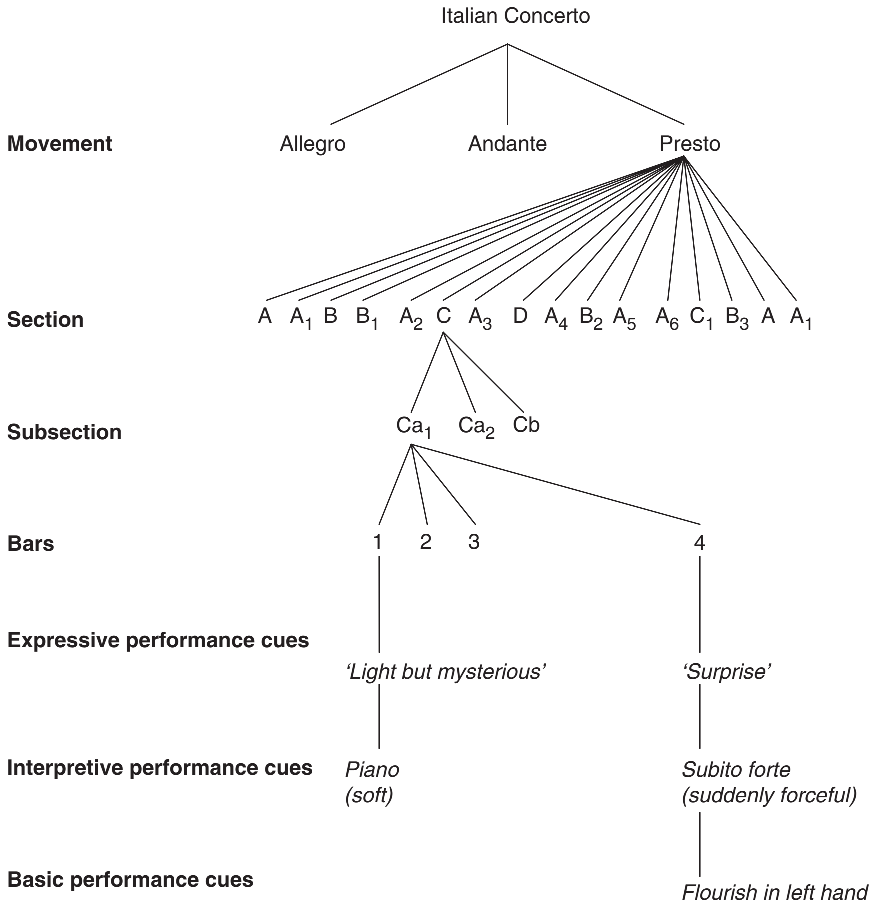

Fig. 33.1 Hypothetical hierarchical retrieval scheme 'unpacked' for Section C of the Presto from the Italian Concerto by JS Bach. Main themes (sections) are represented by capital letters. Section C is 'unpacked' into subsections (Ca1, Ca2, Cb). Subsection Ca1 is further 'unpacked' into its performance cues (adapted with permission, from Chaffin *et al*. 2002, p. 200).

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 schema for rhythm, meter, harmony, and melody, directly link each passage with the next. Each passage is cued only 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 33.1, 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 her learning the Italian Concerto (Presto) by JS 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

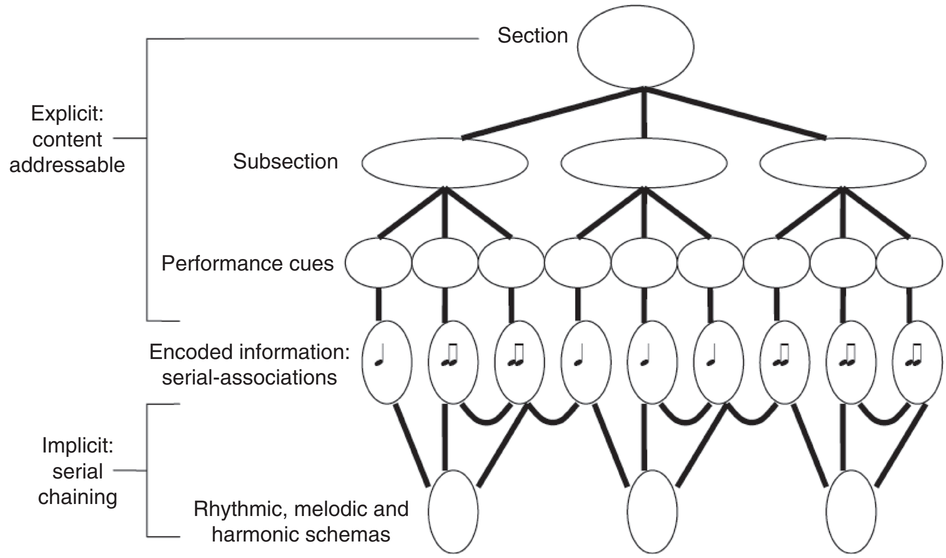

Fig. 33.2 Model of episodic memory for music performance showing separate retrieval organizations for access by content address and by serial associative chaining (adapted with permission from Ericsson and Kintsch 1995).

> about where I was, and which way the switch would go.
>
> Chaffin *et al.* (2002, p. 224)

The musician was talking about the need to practice performance cues. Performance cues are landmarks in the mental map of a piece that an experienced musician maintains in working memory during performance. Because they can be accessed both by serial cuing and directly, by address, they provide a safety net in case serial cuing breaks down. Careful preparation of performance cues makes it possible for soloists to reliably perform challenging works from memory on the concert stage. By repeatedly paying attention to performance cues during practice, the musician ensures that 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 be executed automatically. When things go smoothly, performance cues are a source of spontaneity and variation in highly polished performances (Chaffin *et al.* 2007). 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.[8] *Structural* cues are critical places in the formal structure, such as section boundaries. *Expressive* cues represent musical feelings, e.g., excitement.[9] *Interpretive* cues refer to musical gestures, such as changes of tempo or dynamics. *Basic* cues point to motor memory for critical details of technique, e.g., a fingering that sets the hand up for what follows. Musicians are likely to agree on the musical structure of a piece.[10] They are likely to differ, however, on other cues that are more specific to the performer or instrument. For example, basic performance cues for a cellist include decisions about intonation, bowing, and changing string that are not relevant for a pianist (Chaffin *et al.*

[8] The organization of cues into types here is descriptive and somewhat arbitrary. Other descriptive organizations are possible.

[9] Musical structure and expression are necessarily linked, but expressive cues do not always coincide with structural boundaries (Chaffin *et al.* 2008).

[10] The musical structure of some pieces may, however, be understood in more than one way, e.g., Ginsborg *et al.* (2006).

2008). For solo works, the only performance cues required are those for the individual musician, while for ensemble performance the musicians must also establish shared performance cues to coordinate their actions (Ginsborg *et al.* 2006).

Performance cues are content addressable through their location in the hierarchical organization of the piece (see Figure 33.1). 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 (Chaffin *et al.* 2006; Williamon *et al.* 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 getting an overall artistic image of how the music should sound, focusing on structural and expressive cues (Neuhaus 1973; Chaffin *et al.* 2003). Beyond this commonality, the order in which different types of performance cue are practiced appears to depend on the individual, piece, and situation. What all the experienced performers that have been studied to date have in common is that they practice performance cues. This provides them with a safety net for times when associative cuing fails (Chaffin and Logan 2006).

Conclusion

Though it has a long history in Western classical music, playing from memory is often a source of great anxiety for performers. Pianist Janina Fialkowska talked of the 'terror of forgetting'. Lazar Berman reported that, '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, Chapter 3). Anton Rubenstein wrote that fear of memory failure 'inflicted upon me tortures only to be compared with those of the Inquisition' (Rubenstein 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 of training 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. Memory varies no 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.

Acknowledgements

We thank Mary Crawford, Jane Ginsborg, and Aaron Williamon for helpful comments on previous versions of this chapter.

References

Adams J (1987). Historical review and appraisal of research on the learning and transfer of human motor skills. *Psychological Bulletin*, **101**, 41–74.

Aiello R and Williamon A (2004). Memory. In R Parncutt and GE McPherson, eds, *The science and psychology of music performance*, 167–182. Oxford University Press, New York.

Anderson JR (1978). Arguments concerning representations for mental imagery. *Psychological Review*, **85**, 249–277.

Baars BJ (1988). *A cognitive theory of consciousness*. Cambridge University Press, Cambridge University Press.

Beilock SL and Carr TH (2001). On the fragility of skilled performance: what governs choking under pressure? *Journal of Experimental Psychology: General*, **130**, 701–725.

Bower GH (1981). Mood and memory. *American Psychologist*, **36**, 129–148.

Chaffin R and Imreh G (1997). 'Pulling teeth and torture': musical memory and problem solving. *Thinking and reasoning*, **3**, 315–336.

Chaffin R and Imreh G (2002). Practicing perfection: piano performance as expert memory. *Psychological Science*, **13**, 342–349.

Chaffin R, Imreh G and Crawford M (2002). *Practicing perfection: memory and piano performance*. Erlbaum, Mahwah, NJ.

Chaffin R, Imreh G, Lemieux AF and Chen C (2003). 'Seeing the big picture': piano practice as expert problem solving. *Music Perception*, **20**, 465–490.

Chaffin R, Lemieux A and Chen C (2006). Spontaneity and creativity in highly practiced performance. In I Deliège and GA Wiggins, eds, *Musical creativity: multidisciplinary research in theory and practice*, 200–218. Psychology Press, London.

Chaffin R, Lemieux A and Chen C (2007). 'It's different every time I play': spontaneity in highly prepared musical performance. *Music Perception*, **24**, 455–472.

Chaffin R, Lisboa T, Logan T and Begosh KT (2008). Preparing for memorized cello performance: The role of performance cues. Manuscript submitted for publication.

Chaffin R and Logan T (2006). Practicing perfection: how concert soloists prepare for performance. *Advances in Cognitive Psychology*, **2**, 113–130.

Chase W and Ericsson KA (1982). Skill and working memory. In GH Bower, ed., *The psychology of learning and motivation*, 1–58. Academic Press, New York.

Chase W and Simon H (1973). Perception in chess. *Cognitive Psychology*, **4**, 55–81.

Dennett DC (1991). *Consciousness explained*. Little, Brown and Co., New York.

Deutsch D and Pierce JR (1992). The climate of auditory imagery and music. In D Reisberg, ed., *Auditory imagery*, 237–260. Earlbaum, Hillsdale, NJ.

Dowling WJ (1978). Scale and contour: two components of a theory of memory for melodies. *Psychological Review*, **85**, 341–354.

Englekamp J (2001). *Memory for action*. Psychology Press, Hove, England.

Ericsson KA and Charness N (1994). Expert performance: its structure and acquisition. *American Psychologist*, **49**, 725–747.

Ericsson KA and Kintsch W (1995). Long-term working memory. *Psychological Review*, **102**, 211–245.

Ericsson KA and Oliver WL (1989). A methodology for assessing the detailed structure of memory skills. In AM Colley, JR Beech, eds, *Acquisition and performance of cognitive skills*, 193–215. John Wiley and Sons, Oxford.

Finney SA and Palmer C (2003). Auditory feedback and memory for music performance: sound evidence for an encoding effect. *Memory and Cognition*, **31**, 51–64.

Fornazzari L, Nadkarni S and Miranda D (2006). Preservation of episodic musical memory in a pianist with Alzheimer disease. *Neurology*, **66**, 610–611.

Ginsborg J (2002). Singing by heart: memorisation strategies for the words and music of songs. In JW Davidson, ed., *The music practitioner: exploring practices and research in the development of the expert music performer, teacher and listener*, 149–160. Ashgate Press, London.

Ginsborg J (2004). Strategies for memorizing music. In A Williamon, ed., *Musical excellence: strategies and techniques to enhance performance*, 123–142. Oxford University Press, Oxford.

Ginsborg J, Chaffin R and Nicholson G (2006). Shared performance cues in singing and conducting: a content analysis of talk during practice. *Psychology of Music*, **34**, 167–194.

Ginsborg J and Sloboda J (2007). Singers' recall for the words and melody of a new, unaccompanied song. *Psychology of Music*, **35**, 421–440.

Glenberg AM (1997). What memory is for? *Behavioral and Brain Sciences*, **20**, 1–55.

Greenberg DL and Rubin DC (2003). The neuropsychology of autobiographical memory. *Cortex*, **39**, 687–728.

Hallam S (1995). Professional musicians' approaches to the learning and interpretation of music. *Psychology of Music*, **23**, 111–128.

Hallam S (1997). The development of memorization strategies in musicians: implications for education. *British Journal of Music Education*, **14**, 87–97.

Halpern AR (1989). Memory for the absolute pitch of familiar songs. *Memory and Cognition*, **17**, 572–581.

Halpern AR (1992). Musical aspects of auditory imagery. In D Reisberg, ed., *Auditory imagery*, 1–27. Erlbaum, Hillsdale, NJ.

Halpern AR and Bower GH (1982). Musical expertise and melodic structure in memory for musical notation. *American Journal of Psychology*, **95**, 31–50.

Huron D (2006). *Sweet anticipation: music and the psychology of expectation*. MIT Press, Cambridge, MA.

Krampe RT and Ericsson KA (1996). Maintaining excellence: deliberate practice and elite performance in young and older pianists. *Journal of Experimental Psychology: General*, **125**, 331–359.

Liberman AM and Mattingly IG (1985). The motor theory of speech perception revised. *Cognition*, **21**, 1–36.

Mandler G (1984) *Stories, scripts, and scenes: aspects of schema theory*. Erlbaum, Hillsdale, NJ.

Nelson K and Fivush R (2004). The emergence of autobiographical memory: a social cultural developmental theory. *Psychological Review*, **111**, 486–511.

Neuhauss H (1973). *The art of piano playing*. Praeger Publishers Inc., New York.

Reisberg D (1992). *Auditory imagery*. Erlbaum, Hillsdale, NJ.

Reisberg D (2001). *Cognition: exploring the science of the mind*, 2nd edn. WW Norton, New York.

Rizzolatti G and Craighero L (2004). The mirror-neuron system. *Annual Review of Neuroscience*, **27**, 169–192.

Rosenbaum DA (2005). The Cinderella of psychology: the neglect of motor control in the science of mental life and behavior. *American Psychologist*, **60**, 308–317.

Rubin DC (1995). *Memory in oral traditions: the cognitive psychology of epic, ballads, and counting-out rhymes*. Oxford University Press, New York.

Rubin DC (2006). The basic-system model of episodic memory. *Perspectives on Psychological Science*, **1**, 277–311.

Rubinstein A (1969). *Autobiography of Anton Rubinstein: 1829–1889*, trans. A. Delano. Haskell House Publishers, New York (Original work published 1890).

Schulkind MD, Hennis LK and Rubin DC (1999). Music, emotion, and autobiographical memory: they're playing your song. *Memory and Cognition*, **27**, 948–955.

Squire LR (1987). *Memory and brain*. Oxford University Press, New York.

Talmi D, Schimmack U, Paterson T and Moscovitch M (2007). The role of attention and relatedness in emotionally enhanced memory. *Emotion*, **7**, 89–102.

Thompson CP, Cowan TM and Frieman J (1993). *Memory search by a memorist*. Erlbaum, Hillsdale, NJ.

Tulving E (1962). Subjective organization in free recall of ‘unrelated’ words. *Psychological Review*, **69**, 344–354.

Williamon A and Valentine E (2000). Quantity and quality of musical practice as predictors of performance quality. *British Journal of Psychology*, **91**, 353–376.

Williamon A and Valentine E (2002). The role of retrieval structures in memorizing music. *Cognitive Psychology*, **44**, 1–32.

Williamon A, Valentine E and Valentine J (2002). Shifting the focus of attention between levels of musical structure. *European Journal of Cognitive Psychology*, 493–520.