

Roger Chaffin, Gabriela Imreh & Mary Crawford, *Practicing Perfection: Memory and Piano Performance*. New York: Laurence Erlbaum Associates, 2002. ISBN 0-80-582610-6 (hardcover) \$180.00.

How do concert pianists commit to memory the structure of a piece of music like Bach's *Italian Concerto*, learning it well enough to remember it in the highly charged setting of a crowded performance venue, yet remaining open to the freshness of expression of the moment? Playing to *this* audience, in *this* state, now, requires openness to specificity, to interpretation, a working dynamicism that mere rote learning will not provide. Chaffin, Imreh and Crawford's innovative and detailed research suggests that the key to this skill is a declarative mental roadmap aiding musical performance. This hypothesis is neatly and unintentionally summarized by professional pianist Imreh, who states when learning a new piece of music "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. . ." (Chaffin & Imreh 1997, p.326).

This claim challenges the view that expertise is a kind of hyper-skilled mindlessness, an idea popular in musical lore and phenomenological accounts alike. Phenomenological theorists such as Dreyfus (2002) propose that only learners need overarching cognitive structures or stable internal representations to facilitate their memory; experts are so well experienced in their chosen area that their actions are guided solely by an embodied sense of what feels right in the circumstance. Dejours (2006) takes this one step further by proposing that it is the very bypassing of cognition and pre-established rules in favour of an embodied sense of rightness that makes one an expert in a particular field. Chaffin and colleagues see the source of performance flexibility as lying in the mental road map held in long term working memory (LTWM). They import this concept from Ericsson and Kintsch (1995), along with a few of its problems, as we will show. The road map is thought to provide the higher-level control required for flexible adaptation to varying performance conditions, as well as permitting recovery from failures and sensitivity to the aesthetics or emotional quality of performance.

Our aim in this review, offered in the form of five notes, is to raise points for clarification. Chaffin et al.'s unusual and intensive exploration of the mental cues that guide expert musical performance uses longitudinal data gathered during meticulously observed practice and performance. What was done (in terms of where the pianist started and stopped during rehearsal) is calibrated with what was said about the types of performance cues relevant at different moments. Chaffin et al. offer a highly cognitive, top-down model wedded to an innovative, but particular take on Ericsson and Kintsch's (1995) model of LTWM. The application of LTWM theory to this performance domain is of wider significance for cognitive and applied psychology, in particular other applications of LTWM (eg. to dancers' memory for sequences). Indeed, the nature of retrieval structures – which form the basis of LTWM – cuts to the heart of knowledge organization. We critically analyze several assumptions made by Chaffin about the retrieval structures used by the performer, which we link back to difficulties in the theory of LTWM. Much of our criticism here is a request for clarification and extension, so as to bring empirical wrinkles into alignment with a refined theory. Thus, we aim to tease out slight discrepancies between what was found and what was expected. We discuss the issue of how features of music become performance cues, query the evidence for the causal role accorded to declarative memory, and explore a few complications in the application of LTWM. We consider whether the static hierarchy of cues that forms the current conception of the musical road map may be opened out to include more flexible, dynamic processes and varied instantiations in different performers, contexts and genres.

Note One - Designs on the Subject

Professor Roger Chaffin is a teacher and researcher with the Department of Psychology at the University of Connecticut. His research interests have included the differences between linguistic and factual knowledge (Chaffin 1979), the involvement of semantic processes in word learning and definition (Chaffin 1997; Chaffin & Winston 1991) and eye movements during the learning of a new word (Chaffin, Morris & Seely 2001). Chaffin's largest and most recent body of research has concentrated on music performance. As detailed in Gabriellsson (2003), music performance research has gained momentum over the last few decades, with a shift from measuring performance to developing models mapping how music performance is planned and practiced. Chaffin's work with Gabriella Imreh, a classically trained professional pianist, spans the domains of both music performance and expert memory and is at the forefront of trends in this context. Chaffin, Imreh and Crawford (2002a) provide the most comprehensive statement of Chaffin's research programme with Imreh in their book *Practicing Perfection: Piano Performance As Expert Memory*, however other aspects of this work have been thoroughly developed in many other publications

(Chaffin 2002, 2007; Chaffin & Imreh 1997, 2001, 2002a, 2002b; Chaffin & Logan 2006; Chaffin, Lemieux & Chen 2004; Chaffin, Imreh, Lemieux & Chen 2003). Chaffin's work with Imreh has also formed the basis of research investigating areas of specific interest such as memorisation strategies employed by a jazz musician (Noice, Jeffrey, Noice & Chaffin 2008) and a cellist (Lisboa, Chaffin, Logan & Begosh 2007), the use of shared performance cues by a soprano soloist and conductor (Ginsborg, Chaffin & Nicholson 2006), and broader areas such as issues of gender and subjectivity in music research (Chaffin & Crawford 2007; Chaffin, Imreh & Crawford 2002b).

In his work with Imreh, Chaffin attempts to synthesise previous research findings in the areas of expert memory and music performance. This is achieved by exploring whether the three principles of Chunking, Organisation and Practice [CHOP] shown to govern expert memory in domains which rely substantially on declarative (conceptual) memory (Ericsson & Kintsch 1995), also apply to expert memory in musical performance which relies also on motor and auditory memory (Chaffin & Imreh 2002b). Chaffin and Imreh (2002b) suggest that a musical novice will encode a piece of music purely at the level of motor (procedural) and auditory memory, whilst a musical expert will select performance cues to construct a more detailed overarching cognitive plan of the piece of music at the level of conceptual (declarative) memory. Imreh succinctly describes this process when she states "Eventually, at this level [of practice and expertise], you start to have a sort of a map of the piece in your mind. And you start to sort of focus on certain places in it" (Chaffin & Imreh 2002a, p.208).

Video and audio recordings were made of the majority of Imreh's practice sessions over a period of ten months, as she learned the third movement of Bach's *Italian Concerto* (Presto) to performance standard. An analysis of these recordings yielded Chaffin's data. Chaffin combined qualitative and quantitative techniques by linking self-reported declarative with performative data, thus providing a unique window into the internal processes Imreh used when encoding cues for practice and performance. Although performance of the piece in front of a live audience did occur during practice sessions, the final performance that Imreh was working towards was to be recorded in a studio for a CD. It is interesting to note that whilst this end performance was undoubtedly important, it was conducted without the contingencies and varied demands of a live audience; precisely the kind of factors that might require flexible retrieval of learned material.

In a short follow up study to the initial work, Chaffin unexpectedly visited Imreh twenty-seven months after Imreh's last practice session and asked her to play the piece. She refused, suggesting that mistakes she might make may interfere with her ability to relearn the piece subsequently for performance. Instead, she attempted to write out the first page of the score from memory. This came to be used as an important data source, despite the potential differences in recall processes used when writing notes out on paper as opposed to playing notes on the piano. Imreh's unwillingness to cooperate completely with Chaffin on this occasion illustrates a useful tension present in their relationship at times. Frustration with the research process is evident in Imreh's practice sessions, culminating in statements Imreh makes such as "We are experiencing technical difficulties, Roger, yet again. I cannot stand it. I'm just so furious. I could just kill somebody" (Chaffin & Imreh 2002a, p.160). This underlying tension lessens any fears that findings were the performer's attempts to prove the hypothesis. As a social psychologist, Crawford's role as the 'objective observer', recording the ways in which Imreh and Chaffin managed to resolve their differences and negotiate common ground, is integral in this process and her comments afford rare insight into the research process. In addition to the sheer amount and exquisite detail of data gathered, what is exemplary about this research is the high level of reflexivity and self-conscious attention to methods and process with which it has been imbued.

Note Two – Problematising Performance Cues

UNDERSTANDING PERFORMANCE CUES

According to Chaffin, Western Art music possesses an inherent hierarchical structure that is ready made for use as a retrieval scheme by an expert musician. At the top of the hierarchy are structural cues, music being divided into movements that can be further divided into sections, subsections and bars. Next in the hierarchy are performance cues, which Chaffin divides into three different categories arranged in a top-down hierarchy of expressive, interpretive and then basic performance cues. Performance cues are a subset of features that the musician purposefully selects from all the expressive (musical feelings to be conveyed), interpretive (phrasing, dynamics, tempo, pedalling) and basic (fingering, technical difficulties, familiar patterns of notes) features of a piece. Performance cues function as "features of music that the musician thinks about during performance" (Chaffin, Lemieux & Chen 2004, p. 727), and which "give the musician conscious control of highly practiced motor sequences which would, otherwise, be entirely automatic"

(Chaffin & Crawford 2007, p.158). Lower in the hierarchy than performance cues are the interpretive and basic features of a piece and lowest in the hierarchy are the individual notes in a piece of music (Chaffin, Imreh & Crawford 2002a).

The CHOP principles of expert memory research described above underlie Chaffin's conception of the function of performance cues. The CHOP principles are exemplified in an expert musical performer's memorisation process by the expert chunking new information according to pre-existing structures like chords, scales and arpeggios, organising this information according to the hierarchy inherent in the musical structure of the piece, and then practicing repeatedly to ensure the speedy and efficient retrieval of this information from long term memory. For Chaffin, performance cues function as both facilitators and remnants of the CHOP process, allowing rapid, controlled access to long term memory (LTM), which permits LTM to play a live role in working memory (Ericsson and Kintsch 1995).

RELIANCE ON VERBAL REPORT PROTOCOL DATA

To investigate which cues were important to a performer during practice and performance, Chaffin linked verbal report protocol data with behavioural data measuring the points within the score at which the pianist's practice started and stopped, and the sections which she repeated at different phases of practice. Before investigating more specific issues raised by Chaffin's methodology, it is worth briefly noting that the use of verbal protocol data is in itself controversial. Chaffin's use of verbal report protocol data is sophisticated and in good company: indeed, Ericsson claims to have demonstrated that verbal report protocol can be as rigorous as "traditional process data, such as reaction times and eye fixations" (Schraw, 2005, p. 394). However, ongoing debate about the reliability of this evidence warrants some caution.

RETROSPECTIVE CIRCULARITY

Chaffin's comparison of verbal report protocol data with behavioural data initially appears as a validity check between independent lines of evidence. However, a more thorough investigation of Chaffin's methodology casts doubt over the robustness of this validity check. The verbal report protocol data were gathered from recordings of Imreh's running verbal commentary during practice sessions as she detailed what she was doing and why she was doing it. After transcription and content analysis, comments were categorised as falling into twenty topics in four different groups; basic dimensions (fingering, technical, patterns), interpretive dimensions (phrasing, tempo, dynamics/pedal, interpretation), performance dimensions (memory, musical structure, use of score, attention) and metacognitive topics (evaluation, affect, plans and strategy, slow practice, metronome, learning process, research process, fatigue, editor). Behavioural data were ascertained from transcriptions mapping Imreh's practice trajectory onto a cumulative practice record, graphically displaying the location in the score of each of Imreh's practice segments (the material between each start and stop).

Imreh identified the salient features and cues of the *Presto*. Imreh retrospectively marked basic features (fingering, technical difficulties, familiar patterns of notes), interpretive features (phrasing, dynamics, tempo, pedalling) and performance cues (basic, interpretive and expressive) on three separate copies of the score of the *Presto*. The larger the number of features/cues in a bar, the more complicated that bar was believed to be. To investigate the importance of performance cues and basic and interpretive features, regression analysis was used to analyse whether each of the ten different features/cues that Imreh marked on the scores were predictor variables for the number of times Imreh stopped, started or repeated bars during practice.

There is circularity as a result of retrospective specification of cues that undermines the support offered by the data to the theory. Due to basic and interpretive features and performance cues being marked on the score of the *Presto* retrospectively by Imreh, the regression analysis finding that the ten features and performance cues were significant predictor variables for the number of times Imreh started, stopped and repeated certain bars comes as no surprise. Although the findings of the regression analysis may offer some indication as to the partial reliability of Imreh's verbal report data, it seems unusual that features/cues in the *Presto* are defined solely as those features/cues that Imreh singles out. It seems an obvious point to make, but Imreh would not have singled out elements of the music that she *did not* perceive as impacting on her practice either because she would not have remembered them and/or they would not have been in her conscious awareness during practice.

The definition of features/cues in the *Presto* based solely on Imreh's input is problematic for a number of reasons. Imreh's practice behaviour (starting, stopping and repeating) may have been influenced by musical features that she did not code, however, during statistical analysis this behavior was assimilated to the coding scheme she generated. This could result in a behavioral response being interpreted as a

response to a performance cue when it may have been a response to another uncoded music feature. As a result, a potentially significant number of musical elements are neglected in the statistical analysis (and hence not included in what Chaffin hypothesises to be the contents of LTWM in expert musicians) in favour of a smaller subset of musical elements. It would be interesting to compare those features/cues that Imreh marked on the *Presto* with features/cues marked by an objective expert musician blind to the hypotheses of the experiment and see if there were any discrepancies. The method of generating the list of performance cues in Ginsborg, Chaffin and Nicholson (2006) is even more (deliberately) circular than in the Imreh studies: in that study, musicians' comments made in practice were classified as relating to performance cues only if they matched the musicians' later (post-performance) report of where those cues were (p.169).

DEFINING CUES, FEATURES AND DIMENSIONS

Despite the crucial role accorded to performance cues in Chaffin's hypothesis about expert memory in musical performance, there is a marked and ongoing confusion of the use and meaning of the central terms 'cue', 'feature' and 'dimension', which impedes understanding of the theory. In Chaffin's taxonomy, the word 'dimension' is used as a blanket term to describe basic and interpretive features, performance cues and musical structure (Chaffin 2006, p.381; Chaffin & Imreh 2001, p.344). This creates confusion because 'dimension' is interchangeable with 'feature' for basic and interpretive dimensions (all basic and interpretive features), with 'cue' for performance dimensions (all performance cues) and encompasses switches and sections for musical structure. In addition, Chaffin sometimes substitutes 'cue' with 'dimension' without signaling this explicitly. When prefaced by the word basic or interpretive, whether Chaffin is actually referring to 'feature' or 'cue' in his use of the word 'dimension', can only be discerned by the context in which 'dimension' is used. For example, Chaffin and Imreh (2002a) write "The effects of the three performance dimensions are a surprise. Yes, basic and expressive dimensions affected recall, but in opposite directions." (p.213). From the next sentence ("Recall of bars containing expressive performance cues was better than other bars, whereas the recall of bars containing basic performance cues was worse" (p.213)) it is evident that Chaffin is referring to basic performance cues in his use of the word 'dimensions' however frequent substitutions such as these do not make for easy reading.

Perhaps most confusing is the change in Chaffin's terminology over time. In earlier Chaffin, 'cue' and 'feature' are used interchangeably, an example of which is demonstrated by the definition of performance features by Chaffin and Imreh (2001) as "retrieval cues eliciting successive passages from long-term memory allow[ing] the pianist to keep track of progress through the piece and provid[ing] points of intervention for recovery from a mistake, or for the spontaneous variations that make each performance unique" (p.42). Although cited as the source of this definition of performance features, no such explicit definition exists in Chaffin and Imreh (1997). These performance elements (for want of a better word but to avoid confusion) are referred to as performance features at one point in the text (p.326), marked as performance cues in the diagram on the next page (p.327) and then mentioned in passing as cues for the rest of the text (eg. p.331 and p. 332). Although Chaffin tends to become more precise as research progresses, the legacy of earlier uncertain term definition still pervades his later work and makes it difficult to clearly differentiate important elements in his theory. For example, performance cues are defined as "Features requiring attention during performance" in Chaffin and Imreh (2001, p.43) and then labeled performance dimensions in a table in the same article whilst Chaffin and Imreh (2006, p. 345) reproduce a graph from Chaffin & Imreh (1997) which uses the term 'features' throughout (basic, interpretive and performance features) even though performance cues are never referred to as features anywhere else in the article.

EVIDENCE FOR A HIERARCHY

Chaffin and Imreh (2002b) describe how a musical expert will select performance cues to construct a more detailed overarching cognitive plan of the piece of music at the level of conceptual (declarative) memory. This structure is advantageous to the musical expert because it transforms the performance of the piece from a motoric to a cognitive exercise. If a mistake is made, the piece can be resumed from a nearby previous performance cue rather than from the beginning of the piece as would have to be done if the performer was relying solely on motor memory. Using performance cues is also advantageous because it allows the performer to focus on conveying interpretive and expressive elements of the music. Rather than a performer being solely occupied with ensuring each individual note in a piece is played in the correct sequence at the correct time, the performer instead follows a mental road map, allowing motor memory to fill in the gaps between the performance cue signposts.

The hierarchy of performance cues is important to Chaffin as demonstrated by statements such as “The formal structure of the music provided a hierarchical retrieval structure, organized into sections and subsections, with expressive phrases containing basic and interpretive performance cues . . . ideally, the pianist plays with the expressive cues in the spotlight of attention against a background of basic and interpretive performance cues and structural knowledge” (Chaffin & Imreh 2002b, p.348). However, the evidence that Chaffin presents for the effect of performance cues does not gel with his hypothesis of a neat hierarchical retrieval scheme. Imreh’s practice trajectory does not seem to follow a straightforward path of encoding items at the lowest level of the hierarchy first and then items at higher levels of the hierarchy later. For example, basic dimensions and interpretive cues are still having significant effects during Imreh’s practice sessions leading up to a performance whilst expressive cues have no significant effects (Chaffin & Imreh 2002b). Similarly, in an analysis of the very first time the *Presto* is rehearsed, there is evidence that Imreh’s practice is affected by both overarching structural features of the music and minute details embedded in the piece (Chaffin, Imreh, Lemieux & Chen 2003). Although the hierarchy makes sense in terms of structure for a piece of music, it is unclear why this must result in a hierarchical retrieval scheme. This discrepancy is borne out in the results of Chaffin’s research.

Note Three – Idiosyncrasies in Results

In jazz, musical performance is closer to generating a new composition than playing through an old composition. The courting of spontaneous variation and the lack of a rigid musical score in jazz is a vital difference that separates it from classical music. It provides a challenge to any notion of an invariant hierarchy of cues being used in learning a piece of music to performance standards. Jazz pianists rely on their feelings of the movement to carve new paths through the music, almost functioning like a second composer (Monson 1996). Different performance cue strategies do seem to be adopted by experts depending on the genre of music with which the musical expert is involved. The strategy Imreh uses is different to that employed by the jazz pianist (Noice, Jeffrey, Noice & Chaffin 2008) and the conductor and soloist (Ginsborg, Chaffin & Nicholson 2006).

In Noice et al. (2008) comments during practice were transcribed and classified into nine subcategories and four overarching categories; structure, technique, performance (including improvisation), and metacognitive cues. Pianist starts, stops and repeats were used as the dependent variables in regression analysis, while musical features, performance cues and ratings reported by the pianist were used as predictor variables. There were commonalities in practice patterns, including the “run-work pattern” (p. 68) (where sections that need to be worked on are joined together by longer runs). However, although the cue hierarchy would predict a shift in emphasis as basic cues become less important over practice sessions, equal attention was paid to structure, technique and metacognition. The emphasis right from the first session on expressive cues rather than basic was the biggest challenge to the theoretical hierarchy expected. The authors acknowledge that the pianist concentrated on the overall shape of the piece when they were starting to learn it. So the ‘same principles of expert memory’ were not really found here. Noice et al. had hypothesised that professional jazz musicians will use the same principles of expert memory. But, despite the fact that these results are the opposite of those found by Chaffin and Imreh (2001) - in fact the performance cues used as starting points were expressive cues rather than the expected basic cues – the authors merely acknowledge that it is potentially surprising that expressive performance cues are used before basic performance cues. They emphasise here that establishing the big picture before learning details is characteristic of expert problem solving, even though this was not found in the study with Imreh. The authors note that this shows the jazz pianist concentrating more on the overall shape of the piece when they were starting to learn it. The cues are functioning in different and intriguing ways but the authors smooth over rather than highlight the differences. The authors label all performers as expert and attempt to mould their results around Chaffin’s hierarchical performance cue hypothesis rather than letting the data speak for itself. For example, referring to Chaffin’s work with Imreh, Noice et al. describe the jazz musician as “show[ing] the same kind of attention to musical structure and performance cues observed in earlier studies of experienced musicians in the western classical tradition learning new works for performance” (p.73). As well as being inaccurate, this shuts down the possibility of more fruitful investigation. They even engage in a little hypothesis saving by suggesting that if more practice sessions had occurred then the musician may have refocused attention on performance cues.

We think that the results going counter to the hypothesis when the music derives from a different genre is really intriguing and that if such findings were taken seriously they might open out the theory to an appreciation of the differential application of cues across genres, and individuals. There is evidence of individual difference in cue emphasis for instance in Chaffin and Imreh (2001) where the differences between the regression analysis and comments revealed a retrospective (only) emphasis on the

dynamics of the piece. The authors explained that the pianist only commented on things that were difficult for her, and dynamics were not. This suggests that there may be more idiosyncrasies in what emerges in order and emphasis of cue use than the theory has so far accommodated explicitly. Another instance of this interesting variability in cue use emerges in the work of Ginsborg, Chaffin and Nicholson (2006) on shared performance cues in singing and conducting. Here, variation in cue strategy emerges perhaps due to the requirement of working together. There was certainly an early and consistently elevated use of metacognitive cues (the most frequently occurring cues of all); an emphasis that increased from the first joint session to the last. The uniqueness of contextual requirements is also evident in the shifting definitions of basic and interpretive cues. There are shifts in Ginsborg, Chaffin and Nicholson's (2006) study and in Chaffin, Lemieux and Chen (2004) to accommodate the specificity of the task. There are glimmers of more idiosyncratic cues developed in Ginsborg et al.'s study, both by the singer and in the shared performance cue space (the singer and conductor are long-term musical and life partners) – for instance the use of peculiar imagery: “the picture I have is of the girl who is being dressed for a wedding, and this makes me think of *Les Noces*, it makes me think of the Greek play where a bride is being made ready for Achilles” (p. 185) and the shared idea which emerges of using “a little wiggle” (p. 190). After repeated negotiations, the ‘little wiggle’ became a shared performance cue, with a wiggly line to symbolize a slowing down into the first beat of the penultimate bar with the sung word ‘sing’, which in turn was labeled a ‘gathering point’. They note that they categorized these comments as being about shared interpretive performance cues. Then in the conclusion they return to this example, noting the specific ways in which performance cues function in this context to provide cognitive control of the performance:

For a singer, the adjustments of diaphragm, posture, and vocal apparatus needed in performance have been highly practised to make them automatic. Performance cues can produce subtle adjustments to these automatic motor patterns, for example to make a *ritardando* ‘more minimal’ or to provide ‘a little wiggle’... (p. 190).

The openness of the performance to influences of the specific moment of performance is beautifully captured by the singer as she negotiates using less *rubato* and says; “I’d like it more minimal than that, in this context, maybe I’ll feel differently when I hear it with the band.” (p. 189).

Ginsborg, Chaffin and Nicholson (2006) cite different reasons for retaining control over automaticity – both just to lower the risk of disruption and going wrong (p. 168), and for expressive reasons (pp. 170-171). Though they do not make this point in setting up the study, their conclusion offers a suggestive explanation of the difference between individual and shared performance cues (p. 181). Since cues are meant ‘to control performance’, the coordination required for joint performance means this control function must be more explicit. ‘One reason for studying shared performance cues is that they tend to be more explicit than individual cues because the musicians have to spell out for each other what they have in mind’ (p. 81) – even with two musicians accustomed to working together, most dialogue involved explicit descriptions of the adjustments needed. An unstated but important implication of this is that many individual performance cues need not be explicit. It would be useful to bring this point to bear on the studies of individual memory and performance, and seek possible ways to tap implicit cues.

Note Four – Long Term Working Memory Applied

As we have just seen, Chaffin’s results provide mixed support for the claim that the retrieval cues are hierarchically organized. In order to consider these questions more closely we need to reach back to LTWM theory itself. Chaffin offers no rationale for the claim that the retrieval cues used by Imreh are organized hierarchically, but the idea echoes the classic analysis of the retrieval structures employed by the expert memorizer SF in exceptional digit span recall: SF encoded digits as running times, and used a higher order spatial system for organizing the running times (Ericsson & Kintsch 1995). This hierarchical system allowed both for greater quantity of memorized information, and for flexible retrieval, since SF could access specific digit groups when higher order structures were used as retrieval cues.

Ericsson and Kintsch (1995) applied their account of LTWM to a range of distinct domains. However, their account of retrieval structures is unclear in important respects, and some kinds of retrieval structures described there do not have this hierarchical organization. The case of text comprehension, which Ericsson and Kintsch discuss in most detail, is particularly interesting because it provides a very different picture of retrieval structures to the case of expert memorizing. Notably, in text comprehension the retrieval structure (the text representation formed by the reader) is not hierarchically organized. Indeed, a crucial problem with LTWM theory as it is developed in Ericsson and Kintsch (1995) is that there is no *general* analysis of retrieval structures that clearly covers all of the examples discussed, which are very

diverse, ranging across exceptional digit span recall, text comprehension, mental abacus calculation, mental multiplication, dinner orders, medical expertise, and expert chess. It is one of Ericsson and Kintsch's main points that retrieval structures will vary greatly from case to case, but because there is no clearly articulated general analysis we are left with some uncertainty about how to understand what retrieval structures are, and how they operate differently in the specific cases discussed. It is even less clear how to extend the theory to new cases.

Thus, it is not obvious what kinds of retrieval structure we might expect to find in the case of classical solo piano performance, and accordingly it would be helpful if Chaffin provided more explicit analysis of the choices he has made concerning retrieval structures. Chaffin focuses on the idea that the performance cues serve as retrieval structures, but we can identify a second kind of role for them: they might serve as proximal goals for practice. The pianist pays attention to these musical features because she is adjusting her playing so that it comes to properly respect these features. The performance cues need not also serve as retrieval structures *during* performance, they might simply serve as a scaffold for *attaining* competent performance.

If performance cues do play a role as retrieval structures during performance, it is not clear why *all* of the cues learned during practice should come to be incorporated into LTWM for performance. We should expect from Ericsson and Kintsch's (1995) theory that LTWM is highly constrained by task demands, and it is important to recognize that the demands of performance are quite different from those of practice, and indeed across different phases of practice. Strictly, LTWM includes only information that is retrievable during task performance, and it isn't clear from Chaffin's study that all of the performance cues that are learned during practice are retrievable in the context of performance. Thus, we think that an important issue for further investigation is a more fine-grained analysis of the contents of LTWM, both for performance itself and for the preparatory tasks that contribute performance.

Note Five: Keeping the Lid of the Mind's Box Open

Commenting on LTWM in a popular article, Philip Ross (2006) suggests that, while most people relax with competence, and performance becomes "automatic and therefore impervious to further improvement...by contrast, experts-in-training keep the lid of their mind's box open all the time" (p.69). This is a nice summary of what Chaffin and colleagues offer. Like Chaffin and Imreh, we view skilled rehearsal and performative processes as articulable, accessible, stoppable, modifiable via learning and re-chunkable. But we do not see this as being in complete tension with Dreyfus's phenomenology of everyday expertise. Dreyfus suggests that "an expert's skill has become so much a part of him that he need be no more aware of it than he is of his own body" (cited in Sutton 2007, p.768). The knowledge structures involved in expert skill may well be unconscious, if-then production rules, but we view them as accessible and articulable in the right conditions, and, when conscious, open to interrogation as to their appropriateness to context and to (sometimes) collective modification on the fly. This rendering them conscious and articulable is part of the process of discovering them via self-report protocols or 'thought sampling', and perhaps of their coming into LTWM.

Chaffin seems to embrace motor sequences being chunked according to pre-existing concepts, but not around concepts derived on the fly. Chaffin doesn't stress on the fly construction of retrieval structures - for him, they're built up slowly over the rehearsal process, and are based on the musical structure plus what the pianist brings from her experience. Musical structure seems to dictate which concepts the performer will use for chunking (and the hierarchy they will be organised according to) and this leaves no room for individual genre or performer differences. But, we suggest, there should be room for more 'on the fly' construction even within Chaffin's general picture. There's room firstly for more stress on the on-the-fly decision-making Imreh engages in during practice, as she generates cues. But perhaps Chaffin would argue both that the Ericsson model suggests more deliberate (rather than on the fly) construction (because, as we've seen, the part of the LTWM model which Chaffin uses is that drawn from the work on expert memorizers); and that the nature of this task domain encourages more deliberate construction. Jazz, sport, etc are other matters.

We sketch a differently nuanced model that opens out retrieval structures to individual differences and on-the-fly construction. This picture of dynamic LTWM is midway between the fully pre-learned conceptual LTWM position and the Dreyfusian/fully reactive position. We ask if it is possible to occupy an intermediate position between mindless skill as Dreyfus portrays it and Chaffin's particular take on LTWM.

We suggest skilled performers chunk motor sequences around concepts, pre-existing or derived on the fly depending...on genre, piece, performer, and particular strengths (eg. Imreh could neglect to mention her strengths - dynamics). These concepts can be[come] interlinked to form a music road map.

This interlinking (between cue and motor sequence, cue and cue) is what is being learned during practice – as the salient cues emerge and coalesce, differently over different practice sessions, and differently for performance with or without an audience. Moving through this map occurs via reciprocal priming of cognitive cue from motor action (and emotional response to the music created) priming further cues. Not all cues need to be in LTWM at the same time. These interlinked structures - musical structure scaffolds, genre scaffolds - these concepts can (temporally, as the music flows and unfolds) flow through the performer, bringing into LTWM vast tracts of motor sequences and most relevant, attached performance cues. This information rises into working memory and sinks out of it, but all are differentially more primed in LTWM, and accessible (relative to say other musical pieces known and attached to genre scaffold, but not primed by recent practice and the anticipation of performance).

Chaffin's theory as it stands may apply to expert musical memory in Western Art music but how does it apply to music which has a less defined inherent structure? Is it possible to use performance cues to memorise a piece of modern music that does not have bars, sections, key signatures etc? If so, what shape does this strategy take? How does the use of performance cues in Western Art Music compare to their use in jazz, world music, hip hop etc? What happens with performance cues when an individual has to memorise words as well as play a piece from memory on an instrument? What strategies does an expert employ so that the retrieval of lyrics does not interfere with the retrieval of musical material?

We attempt here to forge the path towards a theory of expert memory in music performance that is more flexible and adaptable to context, genre and individual differences. This view of what it takes to keep the lid of the mind's box open differs slightly from Chaffin and colleagues' account.

Conclusion

The phenomena under study are so complicated it is good to use hypotheses as lightly held heuristics, so that the data are allowed to speak loudly, to modify the structure of theoretical expectations. In opening up new areas we need to go in with hypotheses but should also be open to exploratory feeling around. Good critique reveals assumptions we do not know we are making, and makes them explicit as a means of moving the theory forward. What we have attempted to raise here are a number of notes, about the function of cues, their definition, causal status, whether when used individually they have to be conscious, articulated and explicit to have their effect or whether that arises as a result of shared performances. We've also shown that LTWM is still under construction as it tries to incorporate variability of task demands, remain context-sensitive and specify the nature of retrieval structures. We think it important to notice if genres/individuals make sequences unfold differently acknowledge, and embrace, at this stage of theory-building, explicit acknowledgement where one is unsure of what mechanisms might be operative. With research as rich as this, in a cutting edge linkage between music and expert memory, we chime a few modest notes to engage with the play.

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