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Different roles for prepared and spontaneous thoughts: A practice-based study of musical performance from memory

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Background in music performance. During musical performance, experienced soloists have a mental map of the music in mind. Landmarks in this map remind them of where they are and what to do next.
Background in music psychology. These *performance cues* (PCs) are prepared during practice so that they come to mind automatically, ensuring that the performance unfolds as planned.
Aims. Do musicians use the same PCs in each performance? What other thoughts do they have during performance?
Main contribution. To answer these questions, a singer (the first author) reported the thoughts she had as she practised Arnold Schoenberg's two Songs, Op. 14 (1907-1908), and then again as she performed the songs in a public concert. Seventeen months later, she reconstructed the songs from memory, then performed them and reported her thoughts again. Comparison of the three sets of reports showed that slightly more than half of her thoughts in each of the two performances were PCs, i.e., had occurred during practice, and slightly less than half were spontaneous, new thoughts about the music or performance. The PCs were more stable over time: 17 (25%) occurred in both performances compared to only three (4%) of the spontaneous thoughts. Both PCs and spontaneous thoughts reflected the singer's current concerns, but in different ways. When the singer performed the songs again after the reconstruction, her thoughts were shaped by the memory problems that she had experienced during the reconstruction that preceded the performance. She thought about the PCs that she had needed to stop at and about the new locations that she had just used as starting places.
Implications. PCs are prepared during practice to provide the mental landmarks needed for a secure performance while spontaneous thoughts reflect more transitory experiences and insights.

Keywords: performance cues, singing, memorization.

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Introduction

This article reports an investigation of the first author's memory for two Schoenberg songs that she learned for public performance, an example of what has come to be known as *practice-based* research. We will begin by providing a brief account of practice-based research generally before describing the origins of the specific approach taken in the present study, which is part of an on-going programme of longitudinal case study research involving professional and student musicians, and the project itself.

Performance practice and music performance research

Traditionally, there have been two kinds of research on music performance that can be considered part of mainstream musicology. *Performance practice* research derives from the study of performance in different eras (e.g., Cyr, 2011; Heaton, 2012), and now extends to the study of performance in different cultures (e.g., Grimmer, 2012). This approach uses a range of historical and music analytic methods to understand how different musical cultures approach the task of performance. *Music performance research*, in contrast, uses theoretical frameworks and empirical methods adapted from psychology, and is usually viewed as a branch of music psychology or the rapidly developing new field of performance science (e.g., Hallam, Cross, & Thaut, 2009; Williamon, Edwards, & Bartel, 2011).

Practice-based research

In recent years there has been an effort to encourage a third kind of research in university music departments and conservatoires, whereby composers, performers and teachers undertake and publish research on their own practice (Blain, 2013; Doğantan-Dack, 2012; Gaunt, 2007). This approach is referred to variously as: 'practice-as', 'practice-led', 'performative', and 'artistic' research. We use the term *practice-based research*. One potential benefit of practice-based research is that the techniques and strategies that professional musicians use in the practice studio and on stage can be shared with fellow practitioners and students. More broadly, practice-based research contributes to efforts to understand human skill and creativity in other domains, e.g., nursing (Benner, 2004), surgery (Kneebone, 2011), science (Osbeck, Nersessian, Malone, & Newstetter, 2011), and sports (Ericsson, Krampe, & Tesch-Römer, 1993). Music is particularly well suited to this kind of inquiry because musicians typically engage in regular, daily practice that can easily be recorded to provide an objective behavioural record of their activity and because musical notation provides a flexible and precise tool for describing their activity during practice (Chaffin & Imreh, 2001). Most other areas of human creative endeavour, e.g., literature, science, and sports, lack one or both of these advantages. In some countries the move towards practice-based research in music has been encouraged by government initiatives designed to put funding for higher education in the arts on a common footing with the sciences.

According to the website of the Practice as Research Consortium North West (http://www.miriad.mmu.ac.uk/postgraduate/parcnorthwest/), for example, practice-as research focuses on "questions of contexts, histories and theories within practice training". The term 'practice-as-research' is also used specifically in relation to theatre, dance, film,

video and television performance: the UK Arts and Humanities Research Board (AHRB) funded a five-year project between 2001 and 2006 at the University of Bristol which "aimed to develop national frameworks for the encouragement of the highest standards in representing practical-creative research within academic contexts" (http://www.bris.ac.uk/parip/introduction.htm). A similar project produced the Practice As Research in Music Online (PRIMO) website (http://primo.sas.ac.uk/eprints/). The major funding body for the arts in the UK, the Arts and Humanities Research Council (AHRC) uses the term 'practice-led research'. The guidelines read as follows:

> For your research to be considered as practice-led, your own practice must be an integral part of the proposed programme of research, and the creative and/or performative aspects of the research must be made explicit. … The research carried out should bring about enhancements in knowledge and understanding in the discipline, or in related disciplinary areas. This requirement excludes research to provide content (AHRC Research Funding Guide, November 2011).

In Australia, the term 'performative research' was introduced as a way of recognising the contributions of performers and composers in the Excellence for Research in Australia (ERA) initiative. It is contrasted with both quantitative and qualitative methodologies:

> [When] research findings are presented as such utterances, they too perform an action and are most appropriately named Performative Research. It is not qualitative research: it is itself. [It is] expressed in nonnumeric data, but in forms of symbolic data other than words in discursive text. These include material forms of practice, of still and moving images, of music and sound, of live action and digital code. The 'practice' in 'practice-led research' is primary – it is not an optional extra; it is the necessary pre-condition of engagement in performative research (Haseman, 2006, p. 6).

In Europe, the term used is 'artistic research'. In 2010 the Polifonia Research Working Group of the European Association of Conservatoires (AEC) published *Researching conservatoires: Enquiry, innovation and the development of artistic practice in higher music education*, which defines artistic research as "an umbrella concept ... (i) covering research activities with an artistic knowledge base and artistic outlook and (ii) ... embedded in the conservatoire" (www.polifonia-tn.org).

It would seem, however, that the idea of practice-based research as described in the guidelines and mission statements of these organizations is not well understood. Many of the research projects listed on the relevant websites as examples of practice-based research are perhaps more typical of the more familiar performance practice approach. For example, among the projects listed on the PRIMO website is "An introduction to the Renaissance flute: playing techniques, vocal quality, tuning and fingering; historical design and modern copies [including] performed illustrations from two repertoires (French, c.1530; German, c.1630)", by Nancy Hadden. Similarly, some projects provided as examples of artistic research by AEC institutions clearly fall into the performance practice tradition, to the extent that they include the term 'performance practice' in their titles (e.g., "Extended piano techniques – in theory, history and performance practice", by Luk Vaes). Those that seem most clearly practice-based often involve composers (e.g., "Co-ordination and subordination in harmonic relations" by Adina Sibianu), and, a popular focus, collaborations between composers and performers (e.g., "SHUT UP 'N' PLAY" by Stefan Östersjö). Mine Doğantan-Dack recently made the following useful distinction that we should like to see adopted more widely:

> I use the term 'artistic research' to refer to research activities that are methodologically integrated with an artistic creation and cannot be pursued without art-making. In this sense, the domain of artistic research does not necessarily overlap with that of 'practice-based' research where the practice involved does not always result in an art-product (Doğantan-Dack, 2012, p. 36).

Music performance research on musicians' memorizing strategies

Previous research undertaken by the first author used both music performance and practice-based research approaches to study musicians' memorizing strategies (Ginsborg, 2002, 2003, 2004a, b; Ginsborg & Sloboda, 2007) by observing behaviour, measuring accuracy of recall, length of practice segments, reaction times, number of errors and hesitations, and drawing conclusions based on statistical inference. The studies using the music performance approach involved multiple musicians, more than 100 in all. As is usual in cognitive psychology, experimental conditions were carefully controlled by the investigator. Each musician performed the same tasks in a counterbalanced order. The results could, in principle, be replicated by others.

Practice-based research on a musician's preparation for performance

In the practice-based research studies, by contrast, there was only one musician, the first author (henceforth 'the singer'), who recorded her own practice as she prepared new pieces for public performance (Ginsborg, Chaffin, & Nicholson, 2006a, b; Ginsborg & Chaffin, 2011a; Ginsborg & Chaffin, 2011b). The behaviours observed were part of her normal activities as a musician. The methods were designed to minimize disruption to the singer's normal preparation for performance while providing objective, reliable data about how she did so. Some of the procedures for testing her memory were even based on her normal practices, such as writing out her part from memory before a performance, and, before starting to re-learn a work first performed many years earlier, trying to reconstruct her performance from memory, without looking at the score.

Our approach builds on the example of Hermann Ebbinghaus (1850-1909), who began the modern, scientific study of memory by recording his own ability to recall lists of nonsense syllables. Over the course of a year, he learned and relearned lists, testing his ability to recall them on a pre-established schedule. He then replicated the whole experiment before publishing the results that still underpin our understanding of storage and retrieval in long-term memory (Ebbinghaus, 1885). While less heroic in scale, our practice-based studies similarly provide an objective, behavioural record of a single individual engaged in repeated practice over a long period of time.

Unlike Ebbinghaus, we also drew on the singer's knowledge of the material (the music) and her understanding of her own musical decisions and goals. Professional musicians have a deep understanding of their own learning strategies (Hallam, 1995). Without this important source of information, the objective behavioural record of a musician's practice is relatively uninformative (Chaffin & Imreh, 2001). Self-knowledge of this sort cannot, however, be taken at face value. People are not always the best observers of their own actions or even their own mental states (Ericsson & Simon, 1993; Schooler & Schreiber, 2004). Introspections must be validated against an independent criterion. In our studies, the

musician's detailed reports of her own musical decisions and intentions were compared with the details of her behaviour during practice and in later recall of the score. The comparison allowed us both to understand what she was doing during practice and also to assess the validity of her reports.

Scepticism is valuable in any kind of study. Objectivity is enhanced when investigators take a critical stance towards their own assumptions, motives, and measures, because their own subjective experience and viewpoint play an important role in shaping questions and interpreting evidence (Harding, 1991). Self-reflection of this sort is even more important when the investigator is also the person under study, as in much practice-based research (Chaffin, Imreh, & Crawford, 2002, p. 16; Haseman, 2006, p. 3). To promote reflexivity, our practice-based studies have always involved collaboration between a musician and a cognitive psychologist, in this case, the first and second authors respectively. The first person perspective of the musician and the third person perspective of the scientist complement each other, bringing the empirical methods of cognitive science to "the complexity, uncertainty, instability, uniqueness and value conflicts ....[of] the world of professional practice" (Schön, 1983, p. 14). We believe that our methods provide a useful way for musicians to engage in productive practice-based research while avoiding the pitfalls of introspection.

Longitudinal case study research and the theory of performance cues

Practice-based research tracking individual musicians' preparation for performance from memory and subsequent recall over months or even years can be described as *longitudinal case study research* and has been employed to investigate the formation and use of *performance cues* (PCs) – landmarks for retrieval in a piece of music that is performed from memory. Since the initial research was undertaken with the pianist Gabriela Imreh as she prepared to perform the *Presto* from Bach's *Italian Concerto* (Chaffin & Imreh, 1994; Chaffin et al., 2002; Chaffin, Logan, & Begosh, 2009), the theory of PCs has been developed and refined through a series of longitudinal case studies involving the participation of an increasing number of professional and, latterly, student musicians (Chaffin & Logan, 2006; Chaffin, Lisboa, Logan, & Begosh, 2010; Ginsborg & Chaffin, 2011a, b; Ginsborg, Chaffin, & Nicholson, 2006a, b; Lisboa, Chaffin, Demos, & Aufegger, 2012; Lisboa, Chaffin, & Logan, 2012; Noice, Jeffrey, Noice, & Chaffin, 2008; Williamon & Valentine, 2002). The present study tests hypotheses arising from this theory.

PCs emerge from the features of the musical score to which the musician pays particular attention while practising alone or rehearsing with someone else. These musical features can be categorised as basic, interpretive, expressive, or structural. By the time of the performance the musician no longer needs or wishes to attend to many of these features; they may no longer seem important or they can be produced automatically, without conscious awareness. The remainder are known as 'performance cues'. PCs are those features that are sufficiently important to require attention in performance. Some also serve as cues for memory retrieval during performance and continue to affect subsequent recall, even years after the performance (Chaffin et al., 2002; Ginsborg & Chaffin, 2011a).

The memory that develops spontaneously while learning a new piece takes the form of an *associative chain* in which each passage cues the memory of what comes next (Chaffin,

Logan, & Begosh, 2009). Deliberate memorization makes the motor and auditory chain *content addressable*. A memory is content addressable when thinking of a particular passage enables the musician to start playing or singing there. The musical structure provides the address. Thinking, "Section B, 3rd phrase", activates the sensory-motor memory and the musician starts to play or sing. As a result, musicians start and stop at boundaries between sections and phrases during practice, and recall the beginnings of sections and phrases better than other locations when asked to write out the score months or years later (e.g., Chaffin & Imreh, 2002; Chaffin et al., 2010; Ginsborg & Chaffin, 2011a).

PCs are embedded in the musical structure, directing the performer's attention to particular features of the music. Attention to PCs is also evident in the pattern of starts and stops during practice and effects on recall of the score, months and years later (e.g., Chaffin & Imreh, 2002; Chaffin et al., 2010; Ginsborg & Chaffin, 2011a). PCs are what a performer thinks about during the performance. The musician does not normally think explicitly about where she is in the musical structure, any more than you think about where you are sitting as you read this article. Instead, attention is on the next entry, big leap, or musical climax. The musician knows where these are located within the larger musical structure, but this knowledge remains in the background, providing the context for more explicit thoughts about what she has to do to ensure a successful performance.

In previous studies of the development of PCs, musicians recorded their practice as they prepared a new piece for performance. Around the time of the performance, they provided reports of their PCs by marking them on copies of the score (e.g., Chaffin et al., 2002). Their reports were related to the location of starts, stops, and repetitions during practice from which we concluded that PCs (thoughts during performance) were prepared during practice. In these studies, the musicians were asked to report the PCs that they thought about during performance. They were not asked whether they also thought about other things.

Spontaneous thoughts

The theory of PCs, then, was incomplete. We had not explored the extent to which musicians think *only* about PCs when they perform, or the nature of their other, spontaneous thoughts. These might relate to aspects of the music that they have not noticed before, their own reactions to the music as they are performing it or even the distraction caused by unwelcome and unhelpful thoughts. We set out to rectify this omission, and thereby test the theory that PCs are prepared during practice, in a study directly comparing reports of thoughts during practice and during a public performance (Ginsborg & Chaffin, 2011b). We summarise that study (henceforth referred to as Study 1) here, in order to provide a context for the main study (Study 2) reported in the remainder of this article.

Study 1: Research questions

If musicians only thought about PCs during performance, then all their thoughts during performance would also have occurred previously in practice, as in Figure 1a. This is the situation suggested when PCs are described as a subset of the features attended to in practice (e.g., Chaffin et al., 2002). Alternatively, they might think about PCs and also

about other features or aspects of the music that she had *not* thought about previously, during practice, as in Figure 1b. The only situation that PC theory rules out is that of no overlap, as in Figure 1c.

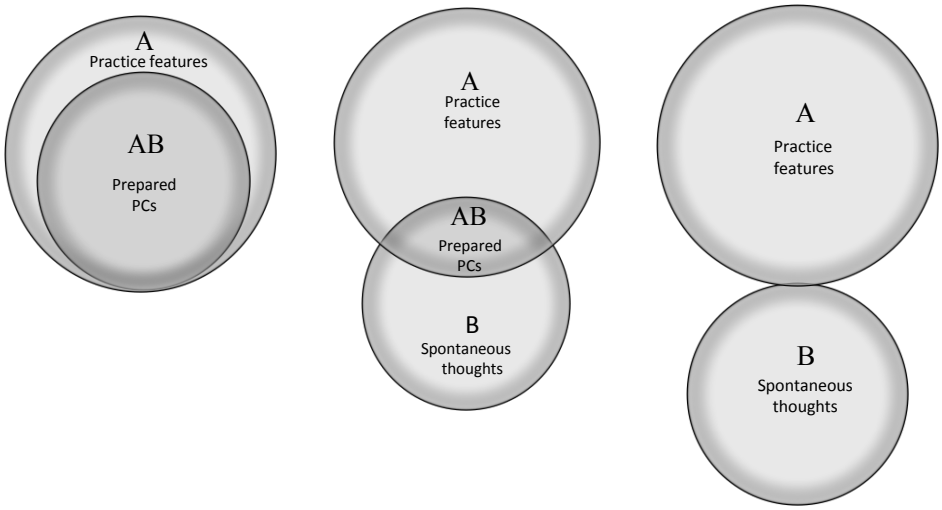


Figure 1. Three possible patterns of overlap between thoughts during practice (A) and performance (B), showing the classification of each type of overlap.

Study 1: Method

Musician. The musician (the first author of this paper) holds a bachelor's degree in music and an advanced diploma in singing, and pursued a career as a singer for nearly 20 years before embarking on a second career in psychology.

Materials. Schoenberg's two songs Op. 14 were composed in 1907-1908 to texts by Stefan George (*Ich darf nicht dankend*) and Karl Henckell (*In diesen Wintertagen*). The singer had learned and performed the songs 25 years earlier but had not sung or listened to them since.

Procedure. The singer practised and re-memorized the songs in five half-hour sessions unaccompanied and accompanying herself, over a three-week period, before rehearsing them in three half-hour sessions with her regular duo partner, the pianist George Nicholson, over a one-week period. In a departure from the method used in previous PC studies she reported the features to which she had attended during the preparation period after the final rehearsal on the morning of the public performance by annotating a copy of the musical score of the two songs, instead of reporting both features and PCs after the performance.

The public performance was a concert given by the singer's voice, clarinet and piano trio in October, 2009. The concert took place in evening of the same day as the final rehearsal.

The programme was planned in such a way that the singer could report her thoughts during performance of the songs immediately after leaving the stage, while the other members of the trio performed a work for clarinet and piano duo. She made the report by annotating a fresh copy of the score, in the same way that she had for the earlier reports. Figure 2 shows examples of annotations made as part of practice and performance reports (upper and lower panels respectively).

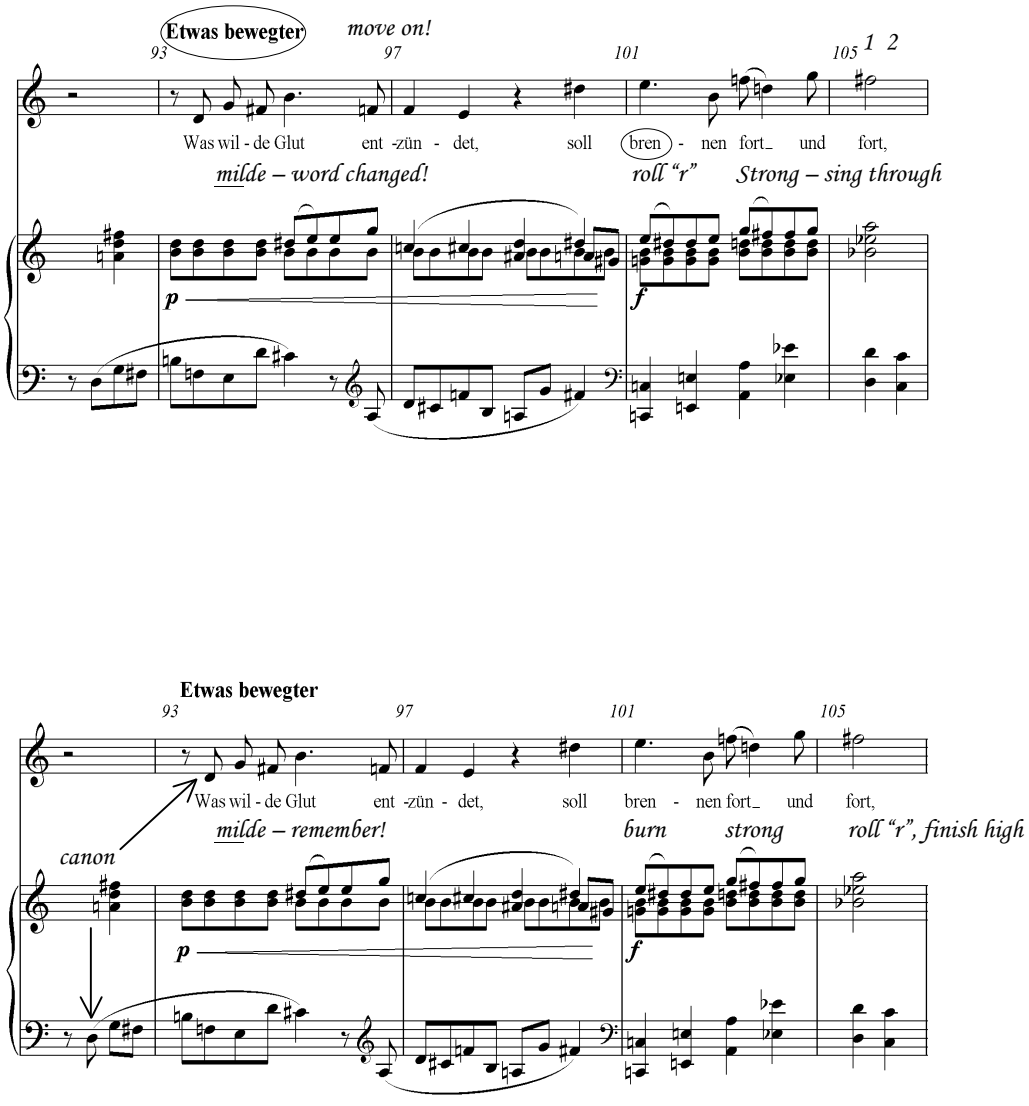


Figure 2. Examples of practice and performance reports (upper and lower panels respectively).

Data. Thoughts were classified according to whether they were reported as occurring during practice, performance, or both (see Figure 1). *Practice features* (which we have hitherto called 'musical features' or simply 'features') were thoughts about the music during practice. Thoughts reported as having occurred during performance were classified as *prepared PCs* if they corresponded to a thought about a similar kind of feature at the same location in practice. Reports during the public performance that did not correspond to practice features were classified as *spontaneous thoughts*. Spontaneous thoughts were further classified as *spontaneous PCs,* if the singer judged that they were useful musical insights that she hoped to retain for future performances (in which case they would function as PCs), or as *extraneous thoughts,* if they were thoughts about context-specific issues that would be unlikely to be helpful in future performances (see Table 1).

Table 1. Classification of thoughts reported as occuring during practice and public performance.

Thought occurred during	Practice	Performance	Nature of thought
1. Prepared PC	yes	yes	Musical decision or insight relevant to any performance
2. Spontaneous PC	no	yes	Musical decision or insight relevant to any performance
3. Extraneous thought	no	yes	Context dependent, specific to current performance
4. Practice feature	yes	no/yes	Musical decision or feature attended to during practice

Reports were also classified according to the aspect of the music they referred to as basic, interpretive, expressive, or shared with the accompanist (see Tables 2a and 2b). The singer did not note structural boundaries – the starts of phrases and verses – after either the rehearsal or the performance; they were too obvious to her to merit attention. She reported them subsequently, after the reconstruction, for use in the analysis described below.

Table 2a..Musical features attended to in practice.

Basic	Intonation	*pitch higher*
	Word (pronunciation)	*t* [end of *dankend*]
	Breath	Breath mark after *Trost*
	Technical	Underlined: *change pitch sideways not up and down!*
	Prepare (pitch, count, listen)	*think through*
Interpretive	Word (meaning)	*strong* (fort)
	Sound	*clear sound*
	Notice musical feature	*notice canon*
	Rubato	wiggle on *du*
	Dynamics	*crescendo*
Expressive	Convey meaning	*milde – word changed!*
Shared	Co-ordinate	*be aware of G's phrase*

Table 2b. Thoughts during performance: prepared and spontaneous PCs and extraneous thoughts

Basic	Intonation	*intonation* (prepared PC)
	Word (pronunciation)	*t* [end of *dankend*] (prepared PC)
	Breath	Breath mark after *Trost* (prepared PC)
	Technical	*roll "r", finish high* (two spontaneous PCs at same location)
	Prepare (pitch, count, listen)	*count [ver]hüllt* (prepared PC)
Interpretive	Word (meaning)	(*leises*) *missing from text* (prepared PC)
	Sound	*enjoy legato* (spontaneous PC)
	Notice musical feature	*notice canon* (prepared PC)
	Rubato	wiggle *more time* (spontaneous PC)
	Dynamics	*decrescendo* (prepared PC)
Expressive	Convey meaning	*growing excitement, more than in rehearsal* (extraneous thought)
Shared	Co-ordinate	*co-ordinate* (spontaneous PC)

Study 1: Results and Conclusions

The relationship of thoughts during practice and thoughts during performance was the one shown in Figure 1b. Just under half of the features to which the singer attended during practice and rehearsal became prepared PCs (50/105 or 47.6%; Ginsborg & Chaffin, 2011b, Appendix, Tables A1 & B1). Nearly two-thirds of her thoughts during performance were prepared PCs (50/82 or 61%; Ginsborg & Chaffin, 2011b, Table 5). The other third were spontaneous thoughts. The singer considered three-quarters (24/32) of these to be useful musical insights that she expected to recur in subsequent performances, or *spontaneous PCs*, bringing the total of PC-like thoughts to 74 (50+24), or 90% of the 82 thoughts during performance. One example was "notice canon" at a location not identified in the practice report. There are several canons in the two songs, which led the singer to believe that the omission may have been an oversight: she had noticed it but failed to report it. Whether she had noticed it in practice or not, the singer was sure she would retain it for future performances. The remaining quarter of non-prepared PCs (8/32) were *extraneous thoughts,* specific to the situation and context of the performance, and judged by the singer unlikely to recur in subsequent performances (Ginsborg & Chaffin, 2011b, Table 6). One example was "fog in throat" (note: this sub-classification of spontaneous thoughts is not shown in Figure 1).

There was no difference between the proportions of basic, interpretive, expressive, and shared features or PCs in the two Schoenberg songs, although there was a trend towards more interpretive and expressive PCs for *In diesen Wintertagen* than for *Ich darf nicht dankend,* χ^2 (2) = 4.78, $p < .09$ (frequencies and percentages of PCs in each song are included below in Table 3 for comparison with those obtained in Study 2).

Study 1 supported one important claim of PC theory, the claim that experienced musicians think mostly about PCs during performance, and appeared to undermine a second important

claim, that PCs are prepared during practice. Most of the singer's thoughts during performance were PC-like even though a third of them had not been prepared during practice.

Study 2: Goals and Hypotheses

The main goal of Study 2 was to test the validity of the classifications we had made of the thoughts reported in Study 1: prepared PCs, spontaneous PCs and extraneous thoughts. We would do this by obtaining reports of the singer's thoughts during a second performance of the same two songs. If the same thoughts reappeared in the second performance, then their classification as spontaneous PCs in Study 1 would be vindicated, along with the claim that most (90%) of the singer's thoughts during the public performance were PCs. On the other hand, if we were wrong and the same spontaneous thoughts did not recur at the same locations, then the earlier estimate that 90% of thoughts during performance were PCs would have to be lowered and we would have to accept that the singer had a substantial number of spontaneous thoughts that were *not* PCs.

We expected the singer to have many of the same thoughts during the reconstructed performance as during the public performance and during practice. Figure 3 shows the hypothesized overlap of the three sets of reports and how we classified each type of overlap. Specifically, we predicted that:

1. Many prepared PCs would recur, i.e., musical features retained as PCs in the public performance would be retained again in the second performance (Area ABC).
2. Other prepared PCs would occur in one performance, but not the other (Areas AB and AC).
3. Spontaneous PCs would recur, i.e., our classification in Ginsborg and Chaffin (2011b) of some new thoughts as spontaneous PCs would be justified by their reappearance in the second performance (Area BC).
4. Spontaneous thoughts from the public performance (Area B) would not recur in the second performance (Area C). (Note: these were classified as 'extraneous thoughts' by Ginsborg & Chaffin, 2011b.)

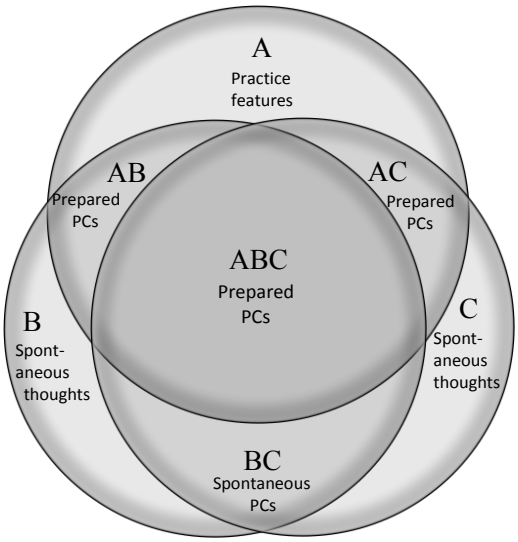


Figure 3. Expected pattern of overlap between thoughts reported for practice A), public performance (B), and reconstructed performance (C), showing the classification of each type of overlap.

The second goal of Study 2 was to provide additional behavioural evidence for the validity of the singer's reports. In previous studies, practice generally started and stopped at boundaries in the musical structure and at PCs more than at other locations with occasional negative effects when the musician avoided starting and stopping in the same locations (Chaffin et al., 2002; Chaffin et al., 2010). So we also looked at where the singer stopped and started as she prepared to give her second performances of the two songs from memory and compared these locations with those of the thoughts that she reported, and boundaries in the musical structure. We hypothesised that:

5. Starts and stops during the preparation for the performance would occur at boundaries in the musical structure and at PCs as in earlier studies of musicians' practice.

Study 2: Method

Musician and materials. These were, naturally, as described for Study 1; preparation and performance were audio-recorded using an iPod with a mini-microphone and subsequently transcribed for analysis.

Procedure. Until now we have referred to first and second "performances" of the two songs. As described in the Method section for Study 1, the first was the public performance in October 2009, preceded by individual practice and joint rehearsal over a period of three weeks. During the first year after that performance the singer, in her role of researcher, carried out data analysis and writing that necessitated consulting the scores of the two songs. A gap of four months was left, however, before she embarked on this second phase

of the investigation, during which she did not look at the scores and refrained from thinking about the songs. The second performance could be described more accurately as a "reconstructed performance exercise" since it was in the form of a single rehearsal session with the pianist in the privacy of the studio, lasting 42 minutes in all. He was reading from the musical score throughout the session, while the singer did not look at it once. The session began with an initial, unsuccessful, attempt by the singer to perform the two songs, unaccompanied, from memory. She then engaged in *in vivo* "reconstruction" of the two songs, with the help of the accompaniment and occasional verbal prompts from the pianist (Ginsborg, Chaffin, Demos, & Nicholson, 2013, have reported a content analysis of their talk during this part of the process). When she felt able to do so, she gave a "reconstructed performance" of each of the two songs, accompanied, with minimal hesitations.

Data. Finally, the singer reported her thoughts during the reconstructed performance.

Analyses. For the purposes of testing Hypotheses 1 to 4 we categorized the thoughts reported for the reconstructed performance in the same way as the previous reports (see Table 2), compared the thoughts reported for the reconstructed performance with those previously reported for practice and for the public performance, and tallied the overlap between the three reports. Annotations were judged to refer to the same thought if they referred to the same musical feature on both occasions and were marked on the score at the same location (beat). Multiple annotations at the same location were tallied separately when they represented separate thoughts.

We tested the possibility that the three reports were unrelated to each other. According to this null hypothesis, the recurrence of the same thought in two different reports could be due to chance. We conducted binomial tests to test this possibility, making the conservative assumption that the chance of the same thought being reported at the same location on two different occasions was 1/12. This assessment was based on our use of 12 categories to classify the different types of thought (see Table 2).

For the purposes of testing Hypothesis 5, we tabulated the number of times the singer started and stopped at each beat during the reconstruction. We used mixed effects models, using the Poisson distribution, to determine whether the locations of starts and stops were related to the locations where thoughts were reported. For these analyses, we considered only the location, not the classification or the content of the thought.

Study 2: Results and Discussion

First, we provide a qualitative account of the process of reconstructing the two songs from memory. Second, we report and discuss the evidence from the reconstructed performance to support or disconfirm Hypotheses 1 to 4. Third, we examine the effect of PCs on the process of reconstruction (Hypothesis 5).

Reconstruction

Figures 4 and 5 (next two pages) show the reconstruction of *Ich darf nicht dankend* and *In diesen Wintertagen* respectively. Although each song is shown separately, work on the two songs was interleaved, as described below.

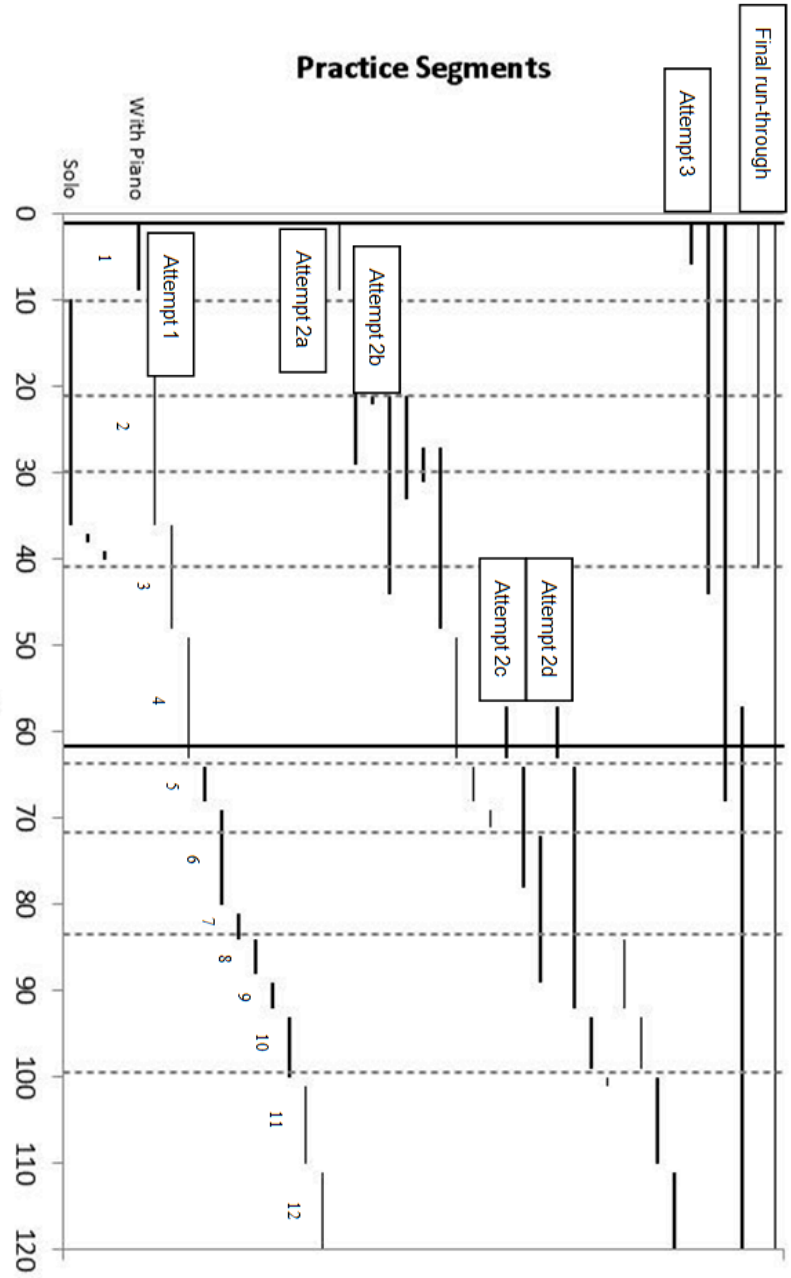
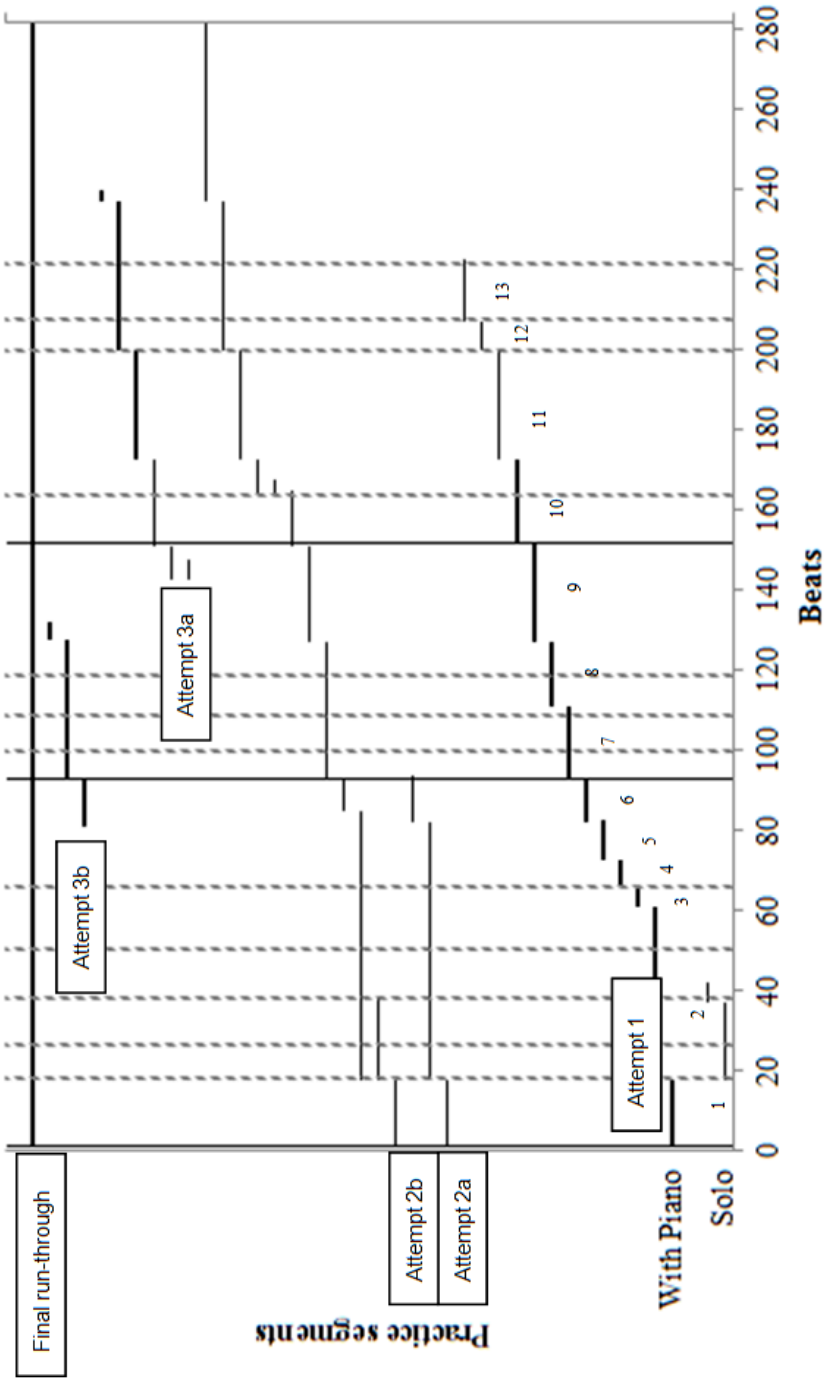


Figure 4 and 5 (next page). Reconstruction of *Ich darf nicht dankend* and *In diesen Wintertagen* without (Solo) and with accompaniment (With Piano).


Final run-through
Attempt 3b
Attempt 3a
Attempt 2b
Attempt 2a
Attempt 1
Practice segments
With Piano
Solo
Beats
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
1
2
3
4
5
6
7
8
9
10
11
12
13

The graphs should be read from bottom to top and from left to right. Each horizontal line represents the uninterrupted performance of the beats shown on the horizontal axis below. Each time the musicians stopped and started again, the record begins again on the next line up. The succession of lines shows where the two musicians started and stopped as the singer struggled to get through each song from memory. Each reconstruction ended with a performance from memory, represented by the uninterrupted horizontal lines at the top of each graph. The bold vertical lines represent the beginnings of verses, the dotted lines the beginnings of phrases. It is evident that the singer tended to start and stop at the beginnings of phrases.

Each graph begins at the bottom with the singer's attempt to sing through the songs without accompaniment ("solo"). Since both songs begin with an introduction for piano, these initial attempts start at beats 9 and 20 for *Ich darf nicht dankend* and *In diesen Wintertagen* respectively. Unaccompanied, the singer remembered very little of each song. She needed the retrieval cues provided by the piano. Even with the piano accompaniment ("with piano"), the reconstruction proceeded haltingly. Most of the singer's difficulties were due to forgetting words, or recalling them incorrectly. When this happened, she was unable to continue and went back and tried again. After about 15 minutes' work on each piece, the singer was able to recall the entire song. The singer then performed each piece from memory with the piano, making only three errors in the melodies: an octave displacement, a doubling of the speed, and at one point singing along with the accompaniment during a solo piano interlude.

Figures 4 and 5 show how the reconstruction of the two songs proceeded. Only the initial attempts on each song, first without and then with accompaniment, are described in detail. At the singer's first attempt on *Ich darf nicht dankend* without accompaniment (Figure 4: Solo), she could recall only the first two and a half phrases of words and melody, from beats 10 to 40:

> *Ich darf nicht dankend an dir niedersinken.*
> *Du bist vom Geist der Flur aus der wir stiegen*
> *Will sich mein Trost an deine[m] something dee dee dum [dee dee]*

As soon as she had made the error of singing "*deinem*" instead of "*deine*" ending on beat 36 (an incorrect grammatical inflection, typically made by singers who are not fluent speakers of German), the singer was unable to recall the words that followed. Although she was able to vocalise beats 37 to 39 ("something dee dee dum") using the correct pitches (shown as the tiny segment, one row from the bottom of the graph, on beats 37 and 38), she sang the last two quavers ("[dee dee]", shown two rows from the bottom of the graph) an octave lower than notated. At beat 40 she stopped and said,

> and I have no idea what happens next... mmm... and then at the end... Could you give me a note for the beginning of the last phrase? No, the last phrase of the song, just give me the opening note, the first note... because all I can remember is... and I think that's just the beginning of it. OK, so I haven't got very much of that at all, I've just got the first two phrases, haven't I?

She then attempted to sing the second song without accompaniment but could only recall the words and melody of the first phrase (Figure 5: Solo, beats 18 to 36), and the melody of the second phrase (Figure 5: Solo, beats 37 to 41).

In diesen Wintertagen nun sich das Licht erhullt
Dee dum dee dee…

…after which she said,

> OK, that's about it. So this time, let's start again, and could you give me – I don't really know what to say, should we start with some accompaniment? Let's see... OK. Well I'll wave at you if I want you to stop, to ask you to stop.

The singer then returned to *Ich darf nicht dankend* and attempted to sing it again from memory, this time with the accompaniment. The first attempt with the piano was made in 12 segments, which are each numbered in Figure 4 (see With Piano, Attempt 1). The first segment (beats 1-9) represents the opening bars of the song for piano solo. The second (beats 10-36) represents the first three phrases and part of the fourth phrase of the song. She sang *"deinem"* again, incorrectly, as in her solo attempt, but this time she was able to retrieve the first half of the next word, *"Weh[mut]"*. Unable to remember the remainder of the words of the fourth phrase (i.e. the rest of the first verse), she vocalised the third segment (beats 36-48) without words, then listened to the interlude played by the piano solo, which is represented in Figure 4 by the fourth segment (beats 49-63). The fifth segment represents the beginning of the first phrase of the second verse (beats 64-68), for which she was able to retrieve the words:

Verharrst du bei dem quälenden Be- […]

She was unable to complete the last word of the phrase, however, and continued wordlessly from beat 69 as far as beat 80 (shown as the sixth segment), making one rhythmic error at beat 72. The seventh segment represents a short piano solo interlude. The singer was supposed to enter at beat 84, the beginning of the third phrase of the second verse, but failed to do so. As the pianist continued to play the accompaniment, she said:

> Stop. Was I due in already? OK, I know how the last phrase goes, it goes "*Und nur*" – could you just give me the note?

The eighth segment represents their re-starting at beat 84, but once again the singer was able to retrieve the words only as far as beat 88:

Und nur mit ihm und […]

and once again had to vocalise, humming the melody only, throughout the ninth segment (beats 89-92). The tenth segment represents eight beats of piano solo (beats 93-100), where the singer should have re-entered after eight beats' rest; instead, as shown in the 11th segment, she entered at beat 101, singing "*eisig*kalten", as printed in the score, instead of the "*eisig*klaren" discovered in the manuscript that she'd worked so hard to remember for the first performance 17 months earlier (see Ginsborg & Chaffin, 2011b).

…eisigkalten, tiefentschlafnen Flusse.

The final segment of Attempt 1 represents the piano solo postlude.

The singer and pianist then returned to the beginning of the song and worked through it again (Figure 4: Attempts 2a to 2d; Attempt 3).

At this point the musicians decided to postpone a final attempt on *Ich darf nicht dankend*, and moved on to the reconstruction of *In diesen Wintertagen*. The first attempt with the

piano accompaniment was made in 13 segments, each numbered in Figure 5 (With Piano, Attempt 1). The first segment represents the introduction for piano solo; the second shows the singer entering at beat 18 and recalling the words and melody as far as beat 60, the end of the fourth phrase.

> *In diesen Wintertagen*
> *Nun sich das Licht verhüllt*
> *Lass uns im Herzen tragen*
> *Einander traulich sagen*

The third segment represents four beats of solo piano interlude (beats 61-65) and the fourth segment (beats 66-72) the start of the fifth phrase of the first verse beginning *"Was uns mit innerm"*. Instead of *"Was uns"* the singer sang *"Das mir"*, disrupting retrieval of the next two words, although she succeeded in retrieving *"Licht"* and *"erhüllt"* in place of "*erfüllt*" (beats 73-82), shown as the fifth segment. After the piano solo (6th segment, beats 82-92), the singer was able to recall both words and melody for the first two phrases of second verse (7th segment, beats 93-106):

> *Was milde Glut entzündet*
> *Soll brennen fort und fort*

When the singer re-entered after the piano solo in beats 107-109 (8th segment), she could not remember the words so vocalised wordlessly instead until the start of the piano solo (beats 127-151; 9th segment). The singer re-entered at beat 152 (10th segment), correctly vocalising the first two phrases of the third verse without words, but doubling the speed in the second phrase (beats 164-171). This should have been followed by an extended piano solo, but the singer incorrectly vocalised the melody (beats 171-199; 11th segment), eliciting the comment from the pianist:

> It's my solo – you don't sing here at all!

The pianist then played the accompaniment to the penultimate phrase (beats 200-206; 12th segment), which the singer failed to sing. As he began the last phrase (beats 207-220; 13th segment), the singer responded:

> It's lovely but I don't remember what happens! I have absolutely no recollection – I don't – If I can't get in I can't carry on – but look I remembered more of it once I had – more of the first verse. OK once again, can we do what we did before?

They started again from the beginning and made it through to the end of the song in two attempts (Figure 5: Attempts 2a and 2b). After reciting the words of the third and then the second verse (Figure 5: Attempts 3a and 3b respectively), the singer felt able to start the final run-through. She made just one error in the words: instead of singing "*erfüllt*" at the end of the fifth line, she repeated "*verhüllt*" from the end of the second line – perhaps because she remembered that she had made an earlier error at that location and wanted to correct it.

Finally, the singer made one more attempt on the first song (Figure 4: Final run-through). Initially, she was unable to progress past beat 42, saying,

> Urggh, urggh, I think that's where I lost it before. *Schmiegen, schmiegen*, then what? *So wird sie zukken*. Once again, it's so short, and it's….

She was successful on her second attempt, however, and the reconstruction session ended after 42 minutes, of which about 10 minutes was spent in talk.

Reconstructed performance

The singer's thoughts during the reconstructed performance were about basic and interpretive features in approximately equal proportion (see Table 3). In contrast with the public performance 17 months earlier, she thought rarely about expression and not at all about intonation or *rubato*.

Table 4 compares the thoughts reported after the reconstructed performance with those reported after the public performance. We grouped them into three broad categories: basic, interpretive, expressive. Differences between their occurrence in the two songs and two recalls were tested using a Fisher's Exact test with *p*-values calculated using 10,000 Monte Carlo simulations. The singer reported more expressive and fewer basic thoughts after the public performance than after the reconstructed performance, $p < .01$. For the reconstructed performance, there was no difference between the two songs in the proportion of thoughts of each type reported, $p = .92$. After the public performance, in contrast, the singer reported a lower proportion of basic thoughts, and higher proportions of interpretive and expressive thoughts for the second song, *In diesen Wintertagen,* $p < .05$.

These differences reflect the differing circumstances of the two occasions. For the reconstructed performance there was no audience and the main challenge was to remember the songs. As a result, the singer thought very little about expression and the focus of her attention was similar for both songs. For the public performance, in contrast, the songs were thoroughly prepared and memorized and the singer's focus was on communicating their meaning and the feelings she wanted to convey to the audience. As a result, she thought more about expression. The difference between the two songs in the public performance was due to a technical problem at the beginning of the first song ("fog in throat") that made the singer think about basic issues. As performance continued without further difficulties, she was able to relax and focus more on expression.

Table 3. Frequency and percentage of thoughts reported following reconstructed performance.

		Ich darf nicht dankend	***In diesen Wintertagen***	**Total**	**% of all thoughts**
Basic	Word (pronunciation)	3	6	9	13.64%
		1	2	3	4.55%
	Technical	4	1	5	7.58%
	Prepare (pitch, count listen)	6	5	11	16.67%
All basic		***14***	***14***	**28**	**42.42%**
Interpretive	Notice musical feature	2	3	5	7.58%
	Dynamics	4	5	9	13.64%
	Word (meaning)	8	10	18	27.27%
	Sound	2	1	3	4.55%
All interpretive		***16***	***19***	**35**	**53.03%**
Expressive		*1*	*2*	3	4.55%
Total		***31***	***35***	**66**	**100.00%**

Table 4. Frequency and percentage of different types of thoughts after public performance and reconstructed performance.

	Public performance, October 2009			**Reconstructed performance, March 2011**		
	Ich darf nicht dankend	***In diesen Wintertagen***	**All PCs**	***Ich darf nicht dankend***	***In diesen Wintertagen***	**All thoughts**
All basic	13 (44.8 %)	13 (24.5%)	26 (31.7%)	14 (45.2%)	14 (40.0%)	28 (42.4%)
All interpretive	8 (27.6%)	26 (49.0%)	34 (41.5%)	16 (51.6%)	19 (54.3%)	35 (53.0%)
Expressive	6 (20.7%)	14 (26.4%)	20 (24.4%)	1 (3.2%)	2 (5.7%)	3 (4.5%)
Shared	2 (6.9%)	0	2 (2.4%)	0	0	0
All thoughts	**29**	**53**	**82**	**31**	**35**	**66**

Figure 6 shows the overlap between the thoughts reported for practice and the two performances separately for the two songs. The number of thoughts reported is represented by the size of each circle, and the number of overlapping thoughts by the size of each overlapping area (Chow & Rodgers, 2005). The figure also shows the number and percentage of thoughts for each area of overlap (percentages are with respect to the total number of annotations in the three sets of reports combined) and indicates the areas in which the overlap observed was unlikely to be due to chance, based on binomial tests with chance set at 1/12.

Hypothesis 1. A quarter of the prepared PCs from the public performance (areas AB and ABC) recurred in the reconstructed performance (area ABC). For *Ich darf nicht dankend,* there were 20 prepared PCs in the public performance, of which 6 made it to the reconstructed performance, binomial test, $p < .01$; for *In diesen Wintertagen,* the corresponding numbers were 11 out of 31, $p < .001$.

Hypothesis 2. Conversely, three-quarters of the PCs in each performance did not occur in the other performance (AB and AC). For *Ich darf nicht dankend,* 14 of the 20 prepared PCs that occurred in the public performance did not reappear in the reconstructed performance, and 5 of the 11 PCs that occurred in the reconstructed performance did not appear earlier, in the public performance, binomial tests, $p < .01$ and .05 respectively. For *In diesen Wintertagen,* the corresponding numbers were 20 out of 31 and 10 out of 21, binomial tests, $p < .001$ and .01 respectively.

Hypothesis 3. One type of overlap between reports was not significantly above chance. Spontaneous thoughts in the public performance (B) rarely recurred in the reconstructed performance (BC). This result does not support our earlier proposal that a substantial proportion of the singer's spontaneous thoughts during the public performance were PCs. For *Ich darf nicht dankend,* only 1 of the 9 spontaneous thoughts in the public performance recurred in the reconstructed performance (area BC), binomial test, $p = .54$. And this was one of the thoughts included in the category of extraneous thoughts (see Hypothesis 4). At beat 17, *"niedersinken"*, the singer wrote "dynamics – unwanted fog in voice" after the public performance and "crescendo – dynamics" after the reconstructed performance, remembering what she had done in the public performance, but not why she had done it.

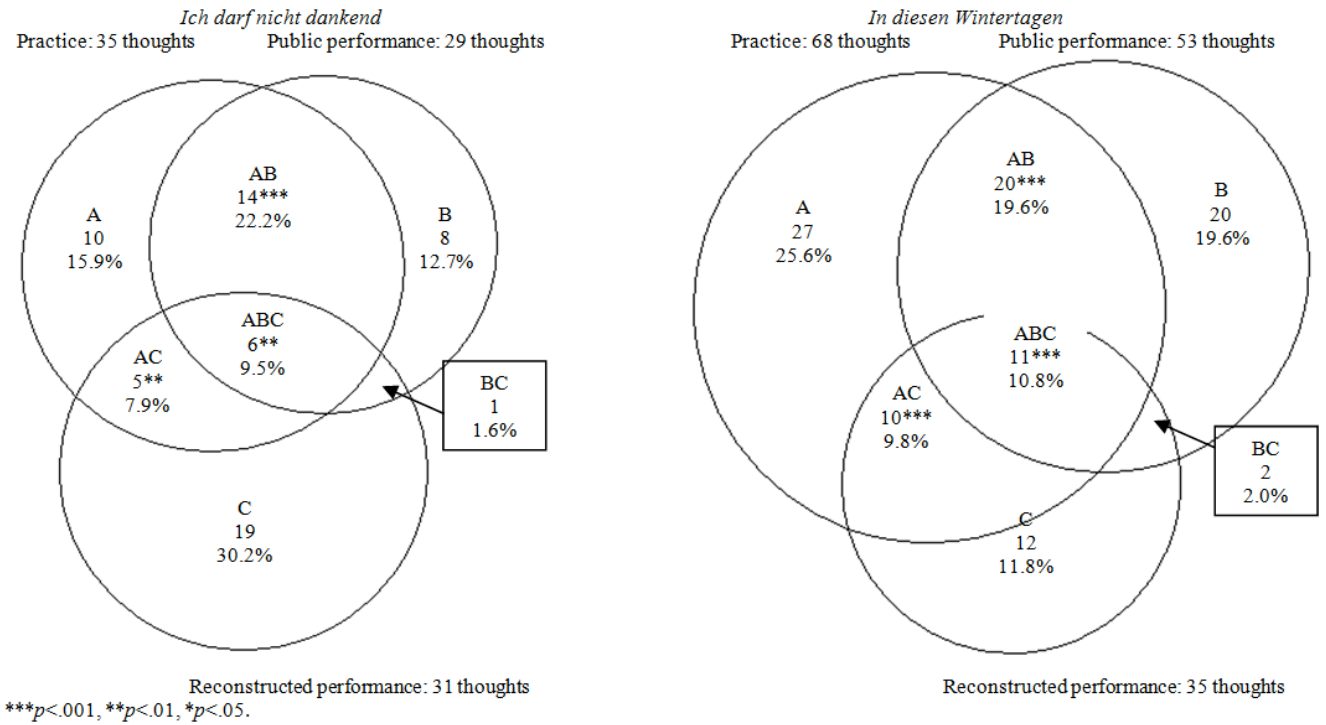


Figure 6. Overlap between thoughts reported for practice (A), public performance (B), and reconstructed performance (C) showing frequencies (area) and percentages separately for the two songs.

For *In diesen Wintertagen,* the corresponding values were 2 out of 22, binomial test, p = .71. Both thoughts were associated with beat 225, *"[se]li[gen Liebe]"* where, after the public performance, she wrote "holy love – enjoy legato". Seventeen months later, during the reconstructed performance, she enjoyed Schoenberg's setting of this phrase once again and noted the thought as "glorious soaring, swooping phrase for 'holy love'".

Figure 7 shows the percentage of thoughts relative to each performance, obtained by computing percentages separately for each performance and then averaging across the two performances. (Figure 6, in contrast, shows absolute percentages, relative to all the thoughts reported in practice and both performances). Figure 7 allows us to describe the proportion of each type of thought that occurred in performance. PCs contributed slightly more than 50%, spontaneous thoughts slightly more than 40%. Figure 7 shows the proportions of PCs that occurred in both performances (Area ABC in Figure 6) separately from those that occurred in one performance but not the other (Areas AB and AC in Figure 6). We will refer to the former as *core PCs* and the latter as *non-core* PCs. Only 4% of the singer's thoughts occurred in both performances but not in practice. We will refer to these as *repeated spontaneous thoughts,* avoiding our earlier assumption that these might be spontaneous PCs. These thoughts were not prepared during practice and there is no evidence to suggest that they differed from other spontaneous thoughts or, as we will see in the next section, that they played a role in the reconstruction. Since we did not identify any spontaneous PCs, there is no longer a distinction to be made between 'spontaneous' and 'prepared' PCs. In Figure 7 and the remainder of this article we therefore refer simply to 'PCs'.

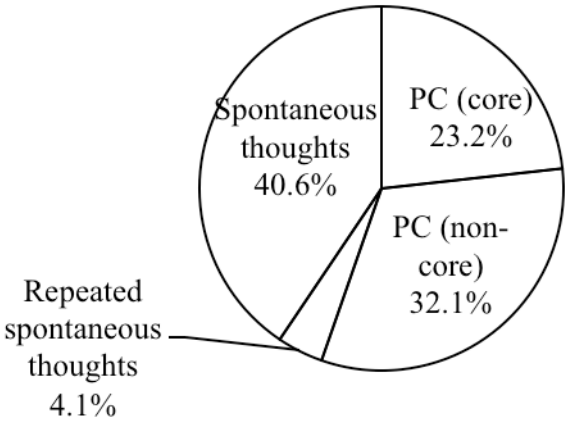


Figure 7. Percentage of different types of PC and spontaneous thoughts during both songs averaged across the public and reconstructed performances.

Effects of PCs on starts and stops during reconstruction

Hypothesis 5. We examined the effect of each type of overlap on starts and stops during the reconstruction, using mixed effects models to compare the locations where the singer reported thoughts after giving the reconstructed performance with the location of starts and

stops. Starts and stops, the dependent variables, were modelled separately, with the two songs and the verses within each song as random effects. The musical structure was represented by five binary, fixed effect predictors that identified where the piano played solo and where each verse and phrase began and ended. The singer's thoughts were represented by six binary predictors representing the location of the thoughts contained in each of the areas of overlap between reports shown in Figure 2: (A) practice, (B) public performance, (C) reconstructed performance, (AB) practice and public performance, (AC) practice and reconstructed performance, (ABC) practice and both performances. The overlap between the public and reconstructed performances (BC) was excluded because of the small number of thoughts. For each type of overlap, three predictors represented locations before, on, and after the beat where thoughts were reported.

Table 5 summarizes the two models, showing which fixed effect predictors significantly influenced starts and stops. The singer started at the beginnings and stopped at the ends of phrases more often than at other locations, suggesting that her memory was organized in terms of phrases, i.e. that she had content addressable access to her memory at the beginnings of phrases. She also started more and stopped less during piano solos. These effects were due to the singer incorrectly anticipating her entries (coming in early), while avoiding corresponding mistakes about where to stop.

Starts and stops during reconstruction were also related to thoughts during the reconstructed performance that followed immediately. The singer started on and before locations where she later reported spontaneous thoughts (C) and stopped after locations where she later reported PCs for the reconstructed performance (AC and ABC). In contrast, starts and stops were not related to the non-core PCs from the public performance 17 months earlier (AB). This was not because the singer did not remember the events of 17 months ago. The effects were very different for thoughts that had been prepared during practice 17 months earlier (AC and ABC) than for new, spontaneous thoughts (C).

The singer's spontaneous thoughts during the reconstructed performance were about places where she had started and stopped during the reconstruction session that immediately preceded it. This is not surprising. She paid attention to these places during the reconstruction in order to use them as starting places so they attracted her attention again during the performance at the end of the session. Note, however, that the singer did not report thinking about the beginnings of phrases, which she also used as starting places during the reconstruction. The same familiarity that made these landmarks useful as starting and stopping places during the reconstruction made them unremarkable during the performance that followed. It was the *new* starting places that attracted her attention and that were reported as new, spontaneous thoughts.

The effect of PCs was very different. During the process of reconstruction, the singer stopped at PCs, rather than using them as starting places. The likely explanation is suggested by the fact that she stopped on the beat *after* the PC, not *on* or *before* it, as was the case for starts. These stops appear to have been retrieval failures. When the singer reached the PC, her memory failed and she could not continue to the next beat. We suggest that during her initial practice, 17 months earlier, the singer had learned to rely on these locations as retrieval cues (PCs). During reconstruction, however, these cues were no longer effective. When the singer reached them, she stopped. This is why the reconstruction was necessary, because the singer needed to refresh her retrieval cues. After she had done

so, she was able to complete the subsequent performance without stopping. The different effects of PCs and spontaneous thoughts on the reconstruction thus reflect the different roles played by the two types of thoughts during performance.

Table 5. Summary of mixed effect models of effects on starts and stops during reconstruction.

		Starts		Stops	
Fixed Effect Parameters		**Estimate**	**SE**	**Estimate**	**SE**
(Intercept)		-3.52***	(0.44)	-1.98***	(0.37)
Piano Solo		1.53***	(0.42)	-0.69*	(0.34)
Verse Starts		1.07	(0.97)	1.60	(1.18)
Verse Ends		1.64†	(0.99)	1.23†	(0.70)
Phrase Starts		2.98***	(0.38)	0.61	(0.44)
Phrase Ends		-0.89	(0.71)	2.10***	(0.36)
Practice only (A)	(Before)	0.25	(0.53)	0.10	(0.43)
Practice only (A)	(On)	0.84	(0.52)	-0.49	(0.52)
Practice only (A)	(After)	-0.86	(0.91)	-0.17	(0.55)
Public performance only (B)	(Before)	-0.64	(0.72)	-0.18	(0.47)
Public performance only (B)	(On)	0.06	(0.48)	-0.19	(0.50)
Public performance only (B)	(After)	-0.44	(0.65)	-0.94	(0.75)
Reconstructed performance only (C)	(Before)	1.29**	(0.45)	0.29	(0.36)
Reconstructed performance only (C)	(On)	1.12**	(0.40)	-0.13	(0.48)
Reconstructed performance only (C)	(After)	0.22	(0.55)	0.33	(0.42)
Practice & public performance (AB)	(Before)	-0.34	(0.56)	0.13	(0.44)
Practice & public performance (AB)	(On)	0.53	(0.52)	-0.58	(0.52)
Practice & public performance (AB)	(After)	-0.61	(0.58)	0.12	(0.45)
Practice & reconstructed perform (AC)	(Before)	—	—	0.73	(0.51)
Practice & reconstructed perform (AC)	(On)	1.09	(0.57)	0.90†	(0.54)
Practice & reconstructed perform (AC)	(After)	0.48	(0.91)	0.97*	(0.45)
Practice & both performances (ABC)	(Before)	-0.40	(0.96)	-0.84	(0.82)
Practice & both performances (ABC)	(On)	0.72	(0.64)	-0.12	(0.54)
Practice & both performances (ABC)	(After)	0.40	(0.62)	1.25**	(0.39)
Random Effects		**Std. Dev**		**Std. Dev**	
Song (intercept)		0.15		0.33	
Verse: Song (intercept)		0.47		0.39	
AIC		276.2		293.1	
BIC		375.9		396.7	
Deviance		226.2		241.1	

***p<.001, **p<.01, *p<.05, † p<.10

Conclusions

Our study involved four important changes in procedure from earlier, longitudinal studies of PC development (Chaffin et al., 2002; Chaffin et al., 2010; Ginsborg, 2011a). First, the singer reported all of her thoughts during performance, not just PCs. This allowed us to identify the presence of spontaneous thoughts, in addition to PCs, during performance. Second, the singer reported her thoughts twice, for two different performances. This allowed us to observe differences in the PCs used in each performance and the core PCs that occurred in both. Third, the singer reconstructed the songs from memory and recorded the process. This provided a record of starts and stops that provided behavioural evidence for the different status of musical structure, PCs, and spontaneous thoughts. Fourth, the singer did not record her initial learning of the songs, thus greatly shortening the process of data collection.

Together, Studies 1 and 2 provide support for the central claim of PC theory that experienced soloists prepare thoughts during practice (PCs) that guide their performance (Chaffin et al., 2002; Chaffin & Logan, 2006; Chaffin et al., 2009; Ginsborg & Chaffin, 2011a). Our results also provide two important clarifications to this claim. First, in addition to thinking about PCs, experienced soloists also have other, spontaneous thoughts during performance that have not been prepared during practice. Although these spontaneous thoughts reflect insights about the music that were similar to PCs, they recur in performance much less frequently than PCs. Second, musicians do not think about exactly the same PCs in every performance. Some PCs persist across performances (core PCs), while others come and go (non-core PCs). We discuss each point in turn.

First, in both performances, the substantial number of PCs confirms the claim of PC theory that experienced performers prepare thoughts for performance ahead of time, during practice. These PCs are mental landmarks that help to ensure that the piece unfolds as planned (Chaffin et al., 2002). The substantial number of thoughts that were *not* PCs was, however, a surprise. As shown in Figure 7, slightly more than half of the singer's thoughts in each performance were PCs; the rest were other spontaneous thoughts, the outcome represented by Figure 1b. When we first obtained this result, in Study 1, we did not believe it (Ginsborg & Chaffin, 2011b). Instead, we thought that a lot of new PCs had emerged spontaneously for the first time during performance. It is possible that, if the singer had continued to practise the songs for a subsequent performance, these spontaneous thoughts might have become established in long term memory as PCs. As it was, she did not practise the songs and her spontaneous thoughts from the public performance did not become PCs. Only three recurred in the reconstructed performance. Since the singer did not stop at these locations during the reconstruction, as she did at other PCs, there is no evidence that they were functioning as PCs.

A similar proportion of new spontaneous thoughts occurred in the reconstructed performance; 47% of the singer's thoughts had not occurred before, during either practice or the first performance. The number of spontaneous thoughts may have been larger than usual due to the short time in which the songs were initially prepared (three weeks). This was not, however, atypical for this musician working on songs of this length and level of complexity. Our results suggest that public performance can often be an important source of musical insight, a belief shared by many musicians (Ostersjö, 2008).

All of the singer's spontaneous thoughts in both performances were about the music or the performance. Some were about musical features that the singer noticed for the first time, e.g., the canon. Others were concerned with what Lehmann and Ericsson (1997) refer to as 'production aspects' of the performance, e.g., "imagine shrug" at *"abzuwinken"*, beat 46, in *Ich darf nicht dankend*; "listen to… harmonic progression", beats 187-191, *In diesen Wintertagen*. None was "extraneous" in the sense of being unwanted or distracting, e.g., thoughts about the audience or about how well the performance was going. Contrary to our suggestion in Ginsborg and Chaffin (2011b, p. 139), the "fog in throat" that the singer experienced at the beginning of *Ich darf nicht dankend* was not a distraction. It may have been unwanted, and it certainly was a problem, but it was highly relevant to the performance and needed to be dealt with.

PCs are thoughts prepared during practice. After Study 1, we thought we had identified an exception to this general principle. We thought that we had identified PCs that appeared, spontaneously, for the first time in the public performance (Ginsborg & Chaffin, 2011b). We were mistaken. Study 2 provided no support for the idea that the spontaneous thoughts that had occurred in the public performance were PCs. Most did not recur and there was no evidence that the three thoughts that did recur functioned as PCs during the reconstruction. Study 2, thus reaffirmed the definition of PCs as thoughts prepared during practice (Chaffin & Imreh, 2002).

This conclusion is consistent with the behavioural evidence from previous studies in which musicians started and stopped at PCs during practice (e.g., Chaffin & Imreh, 2002; Chaffin et al., 2010; Chaffin, 2007; Ginsborg & Chaffin 2011a; Noice et al., 2008). In each case, the musicians practised PCs throughout the learning process, whether practice lasted for just a few minutes or for many months. Prolonged practice is often needed to bring the speed of memory retrieval up to the pace required for performance (Chaffin & Imreh, 2002). Retrieval from long term memory is normally a relatively slow process, requiring several seconds. One of the characteristics of expertise in many domains is the ability to retrieve information in fractions of a second, enabling experts to make snap judgments intuitively without the need for careful analysis (Ericsson & Kintsch, 2005). Development of this ability is a central feature of training in many fields, from chess playing to medical diagnosis (Ericsson, Krampe, & Tesch-Römer, 1993). Music is no exception. The ability to perform reliably in public from memory requires years of training coupled with extended practice of each new piece (Chaffin et al., 2009). Although memory failure during performance is always a possibility, we believe its likelihood can be greatly reduced by thorough preparation of PCs to ensure the optimal use of attention in performance.

Second, the singer in the present study did not use exactly the same PCs in both performances. This is the first evidence that PCs are used flexibly in response to the needs of the moment, a claim first made by pianist Gabriela Imreh in describing the PCs that she used for the *Italian Concerto (Presto)*. She wrote, *"Ideally the [musician performs] with the expressive cues in the spotlight of attention against a background of basic and interpretive performance cues and structural knowledge"* (Chaffin & Imreh, 2002). Imreh estimated that in a good performance she might use only five to ten percent of the basic and interpretive PCs that she had prepared for the *Presto,* suggesting that "the performance is better if you don't use any of them (Chaffin et al., 2002, p. 216). The *Presto* and subsequent studies provided no evidence with respect to this claim because the musicians

reported PCs only once. Because the singer in our study reported her PCs twice, for two different performances, we were able to examine the degree of overlap between the two reports.

Both PCs and spontaneous thoughts reflected the singer's current concerns, but in different ways. The PCs were more stable over time: 17 (23%) occurred in both performances compared to only three (4%) of the spontaneous thoughts (see Figure 7). When the singer performed the songs again after the reconstruction, her thoughts were shaped by the memory problems that she had experienced during the reconstruction that preceded the performance. She thought about the PCs that she had needed to stop at and also about the new locations that she had just used as starting places. Thus, PCs and spontaneous thoughts played different roles. PCs were prepared during practice to provide the mental landmarks needed for a secure performance, while spontaneous thoughts reflected more transitory experiences and insights.

The singer reported a total of 66 PCs, of which 34 (51.6%) occurred only in the public performance, 15 (22.7%) only in the reconstructed performance, and 17 (25.7%) in both performances. The identification of a subset of PCs that occurred in both performances raises interesting questions for future research. It seems likely that the 'core' PCs represented the singer's most important retrieval cues, after the structural boundaries that did not appear in her PC reports but which provide the main contours in any musician's mental map. This conclusion is supported by the finding that core PCs were among the places that she stopped during the reconstruction. What determined which PC's were core and non-core? In our study, there was no difference in the number of basic, interpretive, and expressive PCs in each group and no difference in their locations with respect to beginnings of phrases and verses. We hope that future studies will shed further light on this question.

Since we began our study, two other studies have examined overlap between PC reports for repeated performances of the same piece by the same musician (Chaffin, Gerling, Demos, & Melms, 2013; Lisboa, Chaffin, Demos, & Gerling, 2013). Both studies reported the degree of overlap between reports using Fleiss' Kappa, which measures agreement about where PCs were located and where they were not located, with values ranging from 0 to 1. Lisboa et al. (2013) reported Kappa = .35 and .23 between PC reports for two concert performances of the same piece given on different occasions in the same week by two members of a cello-piano duo who each reported the PCs separately. Chaffin et al. (2013) reported Kappas ranging from .57 to .11 between PCs reports for practice and concert performances of Chopin's *Barcarolle* over a four-year period. These values are comparable to the overlap between PC reports for the public and reconstructed performances in our study, for which Kappa =.35.

Our study is an example of practice-based research. It is the second such study carried out by the first two authors (a comparison between the two was reported in Ginsborg & Chaffin, 2011b) and provides additional support for the general approach as well as the specific findings in relation to performance cues. On the one hand it represents case study research, presenting a systematic account of one individual musician's learning, memorizing, performance, and recall of two songs (in collaboration with her duo partner). On the other hand it can be considered just one piece of a jigsaw puzzle consisting of individual studies of musicians learning pieces. The evidence emerging from a series of

detailed analyses of reported thoughts and observed behaviours supports a theory that has much to offer music performance students, teachers and professional musicians, as well as providing inspiration for those who are considering undertaking practice-based research for the first time.

It was essential to our method that one of the researchers was also the performer. In this instance her first-person perspective was necessary, among other things, to classify which thoughts reported on different occasions were the same and which were different. Her understanding of the music and of her own performances provided an essential check on our interpretation of the data. Studying one's own thoughts is, however, a difficult and risky business, prone to confusion and self-deception (Dennett, 1991). For this reason, we recommend working with a collaborator to provide an outside, third person perspective. The present inquiry was motivated by the fact that the singer was sure that she had spontaneous thoughts. She was also convinced that some of these thoughts would be retained in future performances. They looked and felt just like PCs that she prepared during practice, and she suspected that their absence from her practice reports was an oversight. We hope that we have made a convincing case that Study 2 suggests otherwise. This conclusion was not immediately obvious, however, but emerged slowly over a period of months as a product of discussion and statistical analysis. We needed both first and third person perspectives in order to reach our conclusion, which is a product of both.

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Biographies

Jane Ginsborg used to be a professional singer; in addition to her bachelor's degree in Music she has a first-class honours degree in Psychology, and her PhD thesis reported an investigation of the interaction of words and music in memory, focusing on singers' memorising strategies. She is now Professor of Music Psychology and Associate Dean of Research at the Royal Northern College of Music, Manchester, UK. Her research addresses different aspects of musicians' learning, expert performance and health. She is Managing Editor of *Music Performance Research* (www.mpr-online.net) and current President of the European Society for the Cognitive Sciences of Music.

Roger Chaffin is Professor of Psychology at the University of Connecticut (www.musiclab.uconn.edu). His research on music performance appears in journals such as Psychological Science, Music Perception, and Music Psychology and in the co-authored book, *Practicing perfection: Memory and piano performance*. His earlier work on memory and language appears in journals such as the *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *Cognitive Science*, and *Psychological Bulletin*. He is co-editor of *Memory in Historical Perspective* (1988) and co-author of *Cognitive and Psychometric Analysis of Analogical Problem Solving* (1991). He is a chorister and amateur flautist but prefers the excitement of white-water kayaking to solo musical performance.

Alexander Demos completed his PhD at the University of Connecticut in 2013 where he used dynamical systems techniques to examine the relationship between performers' body sway movements, musical expression, and musical structure. In addition he investigates the role of auditory cues in evoking spontaneous interpersonal synchrony. Currently a postdoctoral fellow at McGill University, he researches the possible mechanisms that allow performers to coordinate their performance. He is an amateur violinist.