British Journal of Psychology (2000), **91**, 353–376 *Printed in Great Britain*

Quantity and quality of musical practice as predictors of performance quality

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Twenty-two pianists, classified into four levels of skill, were asked to learn and memorize an assigned composition by J. S. Bach (different for each level). All practice was recorded on cassette tape. At the end of the learning process, the pianists performed their composition in a recital setting. The resulting performances were evaluated by three experienced piano teachers. From the cassette tapes, values for the quantity of practice were obtained. These values were compared across all four levels of skill and examined to reveal whether they were related to quality of performance. The analyses indicate that the standard deviations of the amount of time spent in each practice session increased systematically with level of skill and that pianists at higher levels spent more time in each practice session. Quantity of practice, however, was not significantly related to quality of performance. Rather, pianists who employed longer practice segments by the middle stage of practice produced better musical, communicative and technical performances. These findings stand in defiance of the argument that quantity of practice is the fundamental determinant of the quality of performance. Instead, they suggest that the content and quality of an individual's practice must be examined when investigating the determinants of musical skill.

Exceptional performances are a source of fascination and intrigue. The knowledge gained by studying such performances can serve to redefine the upper limits of human intellectual and motor achievement and provide evidence as to how specialized skills are acquired (Staszewski, 1988). Consequently, researchers have examined salient characteristics of outstanding performances in many domains: chess (Chase & Simon, 1973a, 1973b; de Groot, 1946/1978; Simon & Chase, 1973), mental calculation (Staszewski, 1988), basketball (Allard, Graham, & Paarsalu, 1980), ballet (Starkes, Deakin, Lindley, & Crisp, 1987) and figure skating (Deakin, 1987). Unlike early explanations, which attribute exceptional ability to divine intervention or special gifts (Murray, 1989), this corpus of research suggests that it may be achieved through extended training. In fact, some researchers (e.g. Ericsson, Krampe, & Tesch-Römer, 1993) have proposed that the fundamental prerequisite of expertise is the accumulation of effortful practice over many years. Regardless of the extent to which this may be true, extensive practice is undoubtedly a vital constituent of expertise.

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Practice makes perfect?

According to Fitts and Posner (1967), skills are acquired over three stages: the cognitive, associative and autonomous stages. Individuals progress towards the autonomous stage and, thus, can perform their acquired skill without being encumbered by interpretive procedures only through practice. Substantial evidence for this claim has led to one of the few 'laws' of cognitive psychology: the Power Law of Practice (see Fitts & Posner, 1967). This law states that the speed of performance of a sensorimotor task increases as a power function of the number of times the task is performed. Some researchers have asserted that the Power Law of Practice also holds true for purely cognitive skills. Anderson (1982), for example, observed that 'at least 100 hours of learning and practice' are obligatory to acquire 'a reasonable degree of proficiency' at any significant cognitive task (p. 369). Subsequently, several mechanisms have been suggested (e.g. chunking, proceduralization, compression and induction) that can account for how practice improves performance on such tasks (see Anderson, 1982, 1987, 1993; Newell, 1990).

Experts, however, do not capture the fascination and intrigue of audiences by simply achieving 'reasonable' degrees of proficiency. Rather, many demonstrate maximal levels of proficiency. How do they achieve such levels? Certainly, Fitts and Posner's (1967) descriptions of the autonomous stage maintains that, once automation of a skill has been achieved, the skill can be improved indefinitely. This implies that practice, too, must continue indefinitely. Two questions emerge: how long must individuals practise to achieve expertise and will extended practice inevitably make perfect?

With regard to the first of these questions, experts spend years developing and refining their skills to meet or, hopefully, surpass the expectations of their audiences. Simon and Chase (1973), in their study of international chess players, found that reaching the level of grandmaster required at least 10 years of practice and experience. This '10-year rule' has been supported by a substantial pool of data from several domains, ranging from mathematics (Gustin, 1985) to long-distance running (Wallingford, 1975). Performing musicians, too, spend years developing and refining their skills (Ericsson *et al.*, 1993; Sloboda, Davidson, Howe, & Moore, 1996; Sosniak, 1985). Ericsson *et al.* (1993), for instance, found that the amount of accumulated practice reported by expert pianists in their sample was estimated at more than 10 times higher than that for amateurs. By the age of 20, pianists in this expert group estimated that they had practised 10000 hours by the start of their performing careers.

If individuals sustain practice for extended periods and acquire automation of many skills required for performance in their domain, will their practice inevitably 'make perfect'? According to the Power Law of Practice, the speed of performance of a sensorimotor task increases as the power of the number of times the task is performed. Therefore, practice, to some extent, makes perfect—or at least faster. Yet, this law does not describe the relationship between practice and performance for skills that require the simultaneous execution of complex cognitive, perceptual and motor tasks, such as those required at expert levels of performance.

Bryan and Harter (1897, 1899) found that mere repetition of a skill results in less than maximal levels of performance. They observed participants practising to increase the speed of Morse Code reception. In plots of letters received per minute as a function of weeks of rehearsal, they discovered that participants encountered two plateaux in their practice. Not all participants improved beyond the second plateau, but those who did displayed extended effort to reorganize and re-structure their skill. Bryan and Harter also demonstrated that participants could overcome these plateaux more quickly when promotions and external rewards required further improvements.

Though subsequent research has indicated that these plateaux are not essential characteristics of skill acquisition (Keller, 1958), research on practice in many domains has confirmed Bryan and Harter's findings that simply accumulating hours of practice will not inevitably result in exceptional skill (e.g. Baltes & Kliegl, 1992; Bower & Hilgard, 1981; Chase & Ericsson, 1981; Gagné, 1970; Kliegl, Smith, & Baltes, 1989, 1990; Trowbridge & Cason, 1932). Rather, practice must be 'deliberate'. Deliberate practice is a highly structured activity with the explicit goal of improving some aspect of performance. Ericsson *et al*. (1993) proposed that, in this type of practice, individuals should invent specific tasks to overcome weaknesses and monitor performance so that further improvements can be made.

The monotonic benefits assumption

Deliberate practice lies at the heart of the theoretical framework proposed by Ericsson *et al*. (1993). The basic assumption of their framework—the 'monotonic benefits assumption'—is that 'the amount of time an individual is engaged in deliberate practice is monotonically related to that individual's acquired performance' (p. 368; also see Krampe & Ericsson, 1995). In other words, quality of performance is directly related to quantity of 'deliberate' practice. They assert that, for individuals to reach expert-level performance, they should maximize the amount of time spent on deliberate practice. This maximization, however, is not easy. It extends over a period of at least 10 years and involves optimization within three constraints: the resource, effort and motivational constraints. The resource constraint can only be met if performers have the available time and energy for deliberate practice, as well as access to teachers, training material and training facilities. To satisfy the effort constraint, individuals must accentuate gains from long-term practice by avoiding exhaustion and limiting practice to an amount from which they can recover on a daily or weekly basis. Finally, performers can satisfy the motivational constraint by viewing deliberate practice as instrumental in achieving further improvements in performance.

To provide evidence for their theoretical framework, Ericsson *et al*. carried out two studies. In the first, they interviewed three groups of 10 violinists, matched for age and sex: (1) the 'best' violinists showed promise for careers as international soloists, (2) the 'good' violinists were of slightly lesser ability and (3) the music 'teachers' planned for careers in music education. Ericsson *et al*. found that all violinists rated practice alone as 'the most relevant activity for improving violin performance' (p. 380). The best and good violinists, however, differed significantly from the teachers in both the amount of practice alone and the amount of weekly practice time. The top two groups practised most often between 10 a.m. and 2 p.m.

and napped more often. By contrast, the teachers' practice was systematically distributed throughout the day, and the amount of napping was significantly less. From these findings, Ericsson *et al*. suggested that since the best and good violinists spent more time practising alone and needed more rest to recover, their practice must have been deliberate. Consequently, they concluded that such commitment to and accumulation of deliberate practice must have resulted directly in the best and good violinists' enhanced performance abilities compared to those of the teachers.

In Study 2, Ericsson *et al*. discovered that the current amount of practice for a group of expert pianists was more than 10 times higher than that of a group of amateurs. They also measured performance on a skill-related task and compared that performance to the amount of deliberate practice reported in interviews and practice diaries. Ericsson *et al*. found that the amateurs' performance on two bi-manual tasks was significantly worse than that of the experts. From these results, Ericsson *et al*. noted that responses required on the bi-manual tasks resembled those which pianists must constantly make during deliberate practice and argued that the experts' proficiency in the performance of these tasks was a direct consequence of increased deliberate practice.

These two studies provide seemingly clear evidence for the relevance of deliberate practice in establishing high levels of musical achievement and supply empirical support for the monotonic benefits assumption. Nonetheless, some limitations emerge. Ericsson *et al*.'s theoretical framework suggests that accumulating deliberate practice depends upon how well individuals satisfy the resource, motivational and effort constraints. The data from Study 1 show that the best and good violinists fulfilled these constraints better than the music teachers. Not only did they consider deliberate practice instrumental in achieving further improvements in performance, but they accumulated more of it and rested more from it than the music teachers. But do all skilled musicians satisfy these three constraints? One notable exception to Ericsson *et al*.'s framework is Louis Armstrong. His general musical abilities flourished as a result of constant exposure to music, but as a poor child growing up in New Orleans, Louisiana, he lacked access to teachers, training materials and training facilities. He did not even own a cornet until the age of 17 (Collier, 1983; Sloboda, 1991). Because Armstrong lacked essential resources throughout his musical development and could not begin deliberate practice until age 17, his musical accomplishments stand in defiance of Ericsson *et al*.'s resource constraint. Despite the absence of resources, Armstrong became one of the most influential figures in early jazz history. Perhaps he compensated for these deficiencies with extra motivation and effort.

In addition, the comparisons resulting from Ericsson *et al*.'s classification of participants in Study 1 (i.e. those who aimed to become musical performers vs. those who aimed to become music educators) were fundamentally flawed. Performers and teachers, though both specialize in the same domain, have a potentially vast number of different goals and motivations for carrying out deliberate practice. Even if the music teachers in this study had devoted as much time to deliberate practice as the performers, their overall level of performance may have remained the same simply because the basic content of their practice differed from that of the performers (i.e. they may have focused on enhancing aspects of skill that do not directly affect performance ability).

Study 2 did not contain this flaw. Still, the conclusions that may be drawn from its results are also limited. The ability spectrum between experts and amateurs in any domain is often enormous. Therefore, to obtain precise evidence as to how certain aspects of performance change as a function of skill, that skill should be stratified into several levels. Since Ericsson *et al*. employed only two such levels, they do not have sufficient evidence to confirm whether their findings will generalize across the entire ability spectrum. If the stratification of musical ability in Study 1 had been valid, their use of two ability levels in Study 2 might have been permissible.

In a subsequent study, Sloboda *et al*. (1996) avoided these two limitations. They also addressed two additional shortcomings. First, they observed that Ericsson *et al*.'s study did not account for musicians who had deliberately practised yet failed to reach high levels of achievement. Sloboda *et al*. elicited information from such musicians in their study. Secondly, they observed that the retrospective estimates of practice made by Ericsson *et al*. lacked reliability because of the lapse of time between the actual activity and recall—some of the retrospective judgments were made after more than 10 years. To deal with this limitation, they verified practice estimates with participants' parents and tested a wider range of young people. The function of the latter was to decrease, on average, the amount of time between the activity and recall.

The retrospective reports indicated a strong relationship between the level of achievement and amount of deliberate practice. Data from practice diaries showed that the highest achievers were more consistent in their patterns of practice from week to week and tended to practice more in the morning. Regardless of group classification, Sloboda *et al*. found that all musicians who reached Grade 8 (on Associated Board and Guildhall School of Music Examinations Grades) had devoted approximately 3300 hours to deliberate practice. Moreover, those who had given up musical performance had fallen behind in their accumulation of deliberate practice as early as age 8. These findings demonstrate that the amount of 'formal, task-oriented' practice (i.e. deliberate practice) was one of the most important elements for determining success as a performing musician, thereby providing support for Ericsson *et al*.'s monotonic benefits assumption.

Aims and objectives of the present study

Does the existing support for the monotonic benefits assumption necessarily indicate that quantity of deliberate practice is the most important prerequisite of expertise? Certainly, the studies by Ericsson *et al*. (1993) and Sloboda *et al*. (1996) provide convincing evidence to support the claim that quantity of deliberate practice is a salient determinant for achieving high levels of skill. The likelihood of a novice reaching maximal levels of performance in any domain without at least some deliberate practice is remote. Musical performers, in fact, have long known that accumulating hours of practice over several years will make them better performers (Noyle, 1987).

Still, the extent to which quantity of practice determines quality of performance is unclear. Is quantity of deliberate practice the sole determinant of expertise? Can the monotonic benefits assumption accurately predict whether the quantity of deliberate practice, accumulated by musicians at the same level of ability as they learn a particular composition, will determine the quality of that composition's performance? Examining such issues may provide useful information for both researchers and performing musicians, testing the scope of the monotonic benefits assumption and revealing whether hours of additional practice will enhance the quality of a specific performance. This paper offers insight into these questions by, first, describing the findings of an empirical study which examines and compares the total amount, frequency and distribution of deliberate practice rendered by 22 pianists—at four discrete levels of ability—whilst preparing an assigned composition for performance. Secondly, the extent to which the musicians' quantity of deliberate practice played a role in determining the quality of their final performances is investigated. Finally, in the light of the presented data, the monotonic benefits assumption is re-evaluated and other possible precursors of expertise are discussed.

Method

Participants

Six piano teachers from south east England were asked to recommend students capable of learning and performing a selected piece of music suited to their level of ability from memory. Thirty-seven pianists were recruited for the study. Of those 37, a complete set of data was collected and analysed for 22 participants. Of the 15 pianists omitted from the analyses, eight did not follow instructions accurately, four felt overwhelmed by the demands of the project, two did not wish to participate and one withdrew because of other personal reasons. Participation was strictly voluntary but encouraged by the piano teachers because the conditions of participation (described below in 'Procedure') were seen to contribute to students' overall musicianship by providing invaluable and challenging performance experience.

The participating pianists were classified into four levels of ability based on the grading system set forth by the Associated Board of the Royal Schools of Music (see Harvey, 1994; throughout this paper, 'level of ability' refers strictly to pianists' general attainment of musical skill). This system contains eight grades, with Grade 1 representing the lowest level of skill and Grade 8 representing the highest. Musicians at Grade 8 are usually considered to possess high performance standards, though just falling short of expertise. The four levels span all eight grades and were stratified as follows: pianists of Grade 1 and 2 standard were placed in Level 1 (two male, three female); Grade 3 and 4 in Level 2 (three male, three female); Grade 5 and 6 in Level 3 (two male, four female); and Grade 7 and 8 in Level 4 (five female). This division of the Associated Board's system was acknowledged as an acceptable stratification of ability by the six participating piano teachers, all of whom had extensive experience in preparing musicians for Associated Board grade examinations and five of whom were, themselves, examiners for the Associated Board. The classification system was strictly upheld, except in one instance when the pianist had never taken grade examinations. In this case, the musician was placed in the most appropriate level, as deemed by the piano teacher. Table 1 lists the means and standard deviations for general characteristics of pianists who successfully completed the study at each level of ability, including age, years of formal training on the piano, length of time with current piano teacher and total number of piano teachers.

The music

The pianists were assigned one piece of music appropriate to their level of ability. All selected pieces were composed by J. S. Bach. The selected pieces for Levels 1 to 4 were, respectively, the Polonaise in G Minor from the *Anna Magdalena Notebook* (BWV Anhang 119), the Two Part Invention in C Major (BWV 772), the Three Part Invention in B Minor (BWV 801), and the Prelude and Fugue in D Minor from the *Well-Tempered Clavier I* (BWV 851). The compositions were chosen with three criteria in mind.

First, while an examination of practice and performance across a group of musicians at the same level would require all the participants to learn the same piece of music, this is not appropriate for a study

Table 1. Means and standard deviations (SD) for general characteristics of the pianists who successfully completed the study

	Level 1	Level 2	Level 3	Level 4
N	5	6	6	5
Age (years)	11·40	13·50	12·83	24·60
SD	2·07	1·76	2·14	3·98
Formal training on the piano (years)	3·45	4·33	5·42	13·62
SD	1·01	2·44	1·02	5·57
Time with current teacher (years)	1·47	1·36	3·22	1·20
SD	1·92	1·28	1·78	0·82
Number of piano teachers	1·60	2·00	1·67	4·00
SD	0·55	1·10	0·82	1·58

Table 2. General characteristics of the assigned compositions

	Level 1	Level 2	Level 3	Level 4
Composition	Polonaise in G Minor from the *Anna Magdalena Notebook* (BWV Anhang 119)	Two Part Invention in C Major (BWV 772)	Three Part Invention in B Minor (BWV 801)	Prelude and Fugue in D Minor from the *Well-Tempered Clavier I* (BWV 851)
Time signature	3/4	4/4	9/16	Prelude: 4/4 Fugue: 3/4
Mean tempo $\left(\frac{\text{Beats}}{\text{Minute}}\right)$	76	70	76	Prelude: 60 Fugue: 66 Combined: 63
Number of bars	16 (no repeats)	22	38	Prelude: 26 Fugue: 44 Combined: 70
Number of beats	48 (no repeats)	88	114	Prelude: 104 Fugue: 132 Combined: 236

examining musical skill at several levels. A single piece would be too easy for some musicians and too difficult for others. The four compositions selected for this study were appropriate to the overall competence of musicians in each of the four groups. The pieces were specifically chosen to be consistent in style (i.e. Baroque) and composer (i.e. Bach). Nevertheless, the analyses presented in this paper are interpreted and discussed with possible between-level differences in mind.

Secondly, many studies investigating musical practice and memorization have required participants to learn short, musical excerpts (Brown, 1928, 1933; Rubin-Rabson, 1937, 1939, 1940a, 1940b, 1941a, 1941b). Such excerpts do not represent the standard repertoire from which musicians draw when preparing for performance and do not, therefore, provide naturalistic means to examine musical skill. Consequently, the conclusions that can be extracted from these studies are limited. The pieces selected for this investigation were intended to represent the standard repertoire at each of the four ability levels.

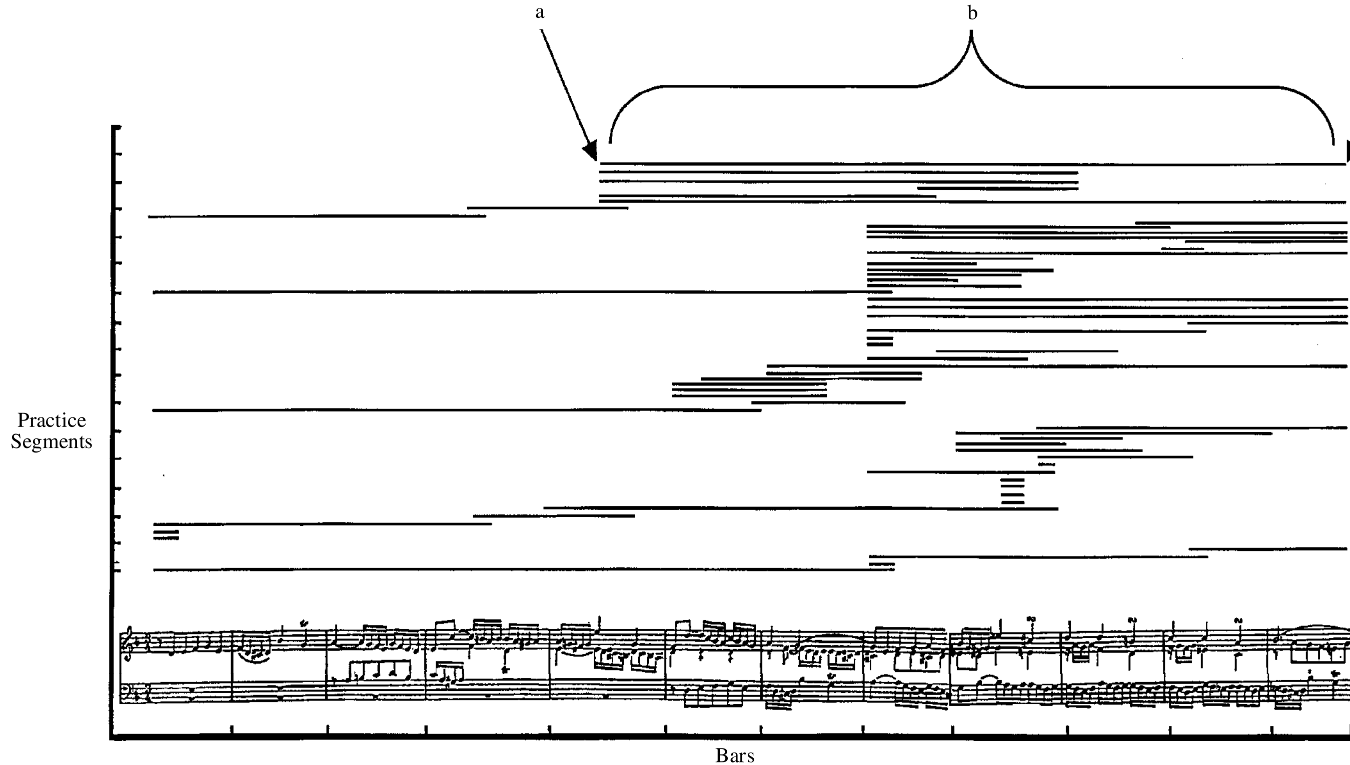

Figure 1. A sample from the cumulative records showing the segments of the music played taken from one of the middle practice sessions of a pianist at Level 4 practising the Fugue in D Minor. The x-axis represents bars of the music and the y-axis depicts the cumulative number of practice segments. The beginning of each horizontal line indicates the point at which the pianist started playing the composition (a). The distance from left to right within each horizontal line corresponds to the size of the practice segment (b). The end of each line denotes the point in the music at which the pianist stopped playing (c). Each new line, reading from bottom to top, indicates that the pianist stopped and restarted.

Indeed, works composed by Bach are amongst pianists' repertoires at all levels of ability. From the simple pieces found in the *Anna Magdalena Notebook* to the challenging preludes and fugues of the *Well-Tempered Clavier*, Bach's compositions are used as measures of musical competence for beginners and concert soloists alike.

Finally, the compositions had to be challenging for the pianists, not only in terms of sheer execution and memorization but also in terms of musicality and musical communication. The selected compositions certainly fulfil this criterion. In fact, much of Bach's keyboard music 'departs from standard conceptual or motor patterns. Most bars, even half bars must be learned of themselves' (Chaffin & Imreh, 1997, p. 319).

The four assigned compositions were suggested and agreed upon by the participating piano teachers according to these three criteria. General characteristics of the selected compositions, including time signature, mean tempo and the total number of bars and beats in each piece are listed in Table 2.

Procedure

Systematic observations of practice. The pianists were asked to record all practice for their assigned piece on cassette tape. At the beginning of each practice session, pianists were asked to announce the current date and time so that information about the frequency and regularity of practice could be examined. The participants were invited to comment, either on tape or in writing, on any relevant aspect of the learning process (these comments were subsequently transcribed by the first author). In addition, pianists were asked to note and describe all practice carried out away from the piano, including singing the music and analysing the score. Participants were informed at the outset of the study that they would be required to perform the assigned piece from memory in a recital setting, attended by their teachers, parents and fellow music students. The time and location of each recital was arranged by the respective music teacher as part of students' regular curriculum (all participating teachers required their students to perform in 'end of term' recitals). No restrictions on the amount of time or the number of practice sessions were placed upon the pianists, except for those normally affixed by themselves or their music teachers.

Performance evaluations. The 22 recital performances were recorded on videotape and were evaluated by three experienced piano teachers, two of whom were also experienced examiners for the Associated Board of the Royal Schools of Music. Evaluations were made according to the three guiding principles set forth by the Associated Board: musical understanding, communicative ability and technical proficiency. Performers were scored for each of the above performance aspects and on overall performance quality. Performances were rated on a scale from 1 to 12, with 12 as the best rating. This 12-point system was partitioned into the same four areas of achievement as awarded by the Associated Board: Distinction (10–12), Merit (7–9), Pass (4–6) and Below Pass Standard (1–3). The reduction of the Associated Board's grading scale from 24 to 12 points was carried out to bring the point range to levels at which psychometric properties are better understood (see Ray, 1993).

Interviews and teacher evaluations. Following each performance, the pianists were interviewed about the practice and memorization process and asked to comment on the project itself, including its design and implementation. The interviews were transcribed by the first author. Responses to questions were, in general, one to two sentences long. Additional information about the pianists was obtained from their music teachers. The teachers were asked to rate each of their students in comparison with other pianists at their general level of ability on a 6-point scale (with 6 as the best rating) on the following 12 aspects of skill: overall ability, 'natural ability', musicality, technique, aural ability, ability to memorize, amount of practice, effectiveness of practice, self-discipline, persistence, speed of learning and eagerness to play the piano.

Cumulative records

The recorded practice sessions were transcribed into cumulative records for each pianist. These records contained both quantitative and qualitative information on the learning process as a whole and on each individual practice session (a practice session was defined as a discrete period of time, of variable length, in which musicians practised the assigned composition either at or away from the piano). The records documented characteristics of practice such as the total time spent practising, the number of days encompassed within the learning process (from the first practice session up to the final performance), the number of practice sessions in the learning process, the number of practice sessions per day and the time spent in each practice session. In addition, graphs were plotted for each practice session showing starting and stopping points for the segments of music played by each pianist. The graphs—with the x-axis representing bars of the music and the y-axis depicting the cumulative number of practice segments—represent the sequence of segments of the music executed by a particular pianist during a given practice session. Such graphs were originally introduced by Chaffin and Imreh (1997). Figure 1 displays a graph taken from one of the middle practice sessions of a pianist at Level 4 practising the Fugue in D Minor. The pianists often corrected one or two notes whilst continuing to play through the music. This type of practice is analogous to a stutter in speech. Such stutters were not included in the cumulative records. All graphs were transcribed from the cassette tapes by the first author.

Results

Individual differences: age and teacher evaluations

Large individual differences can exist between musical performers, possibly arising from discrepancies in training, experience, learning styles and preferred instrument. Such differences have the capacity to introduce confounds into planned within- and between-level comparisons of musicians who span the ability spectrum, thereby making the identification of cognitive characteristics that will generalize across all skilled musicians troublesome. In this study, within-level differences were controlled for by (1) having teachers recommend students who had previously taken grade examinations (such was the case for all but one pianist) and (2) strictly categorizing the students into ability levels based on their achieved grade. To determine whether differences between the students at each ability level were such as to rule out between-level comparisons, the levels were compared with respect to mean age and scores on teacher evaluations (see Table 1 for mean values for age and Table 3 for the means and standard deviations for each level of ability on teacher evaluations). The data were analysed by a one-way analysis of variance (ANOVA) with age and each of the 12 aspects rated by teachers as the dependent variables and ability level as the independent variable.

The analyses revealed that the four levels differed significantly in terms of age ($F(3, 18) = 6{\cdot}00$, $p < {\cdot}01$). Bonferroni *post hoc* comparisons indicated that age was significantly greater for pianists in Level 4 than for those in Levels 3 ($p < {\cdot}05$), 2 ($p < {\cdot}05$) and 1 ($p < {\cdot}01$). Consequently, age has been entered as a covariate in all between-level comparisons. No significant differences, however, emerged between the levels with respect to the 12 aspects rated by teachers, suggesting that the participants at each level were comparable on these aspects to other musicians who had achieved the same standard in Associated Board examinations ($p > {\cdot}05$ for each of the following: Overall Ability, $F(3, 18) = 1{\cdot}75$; Natural Ability, $F(3, 18) = 1{\cdot}80$; Musicality, $F(3, 18) = 3{\cdot}05$; Technique, $F(3, 18) = 1{\cdot}67$; Aural Ability, $F(3, 18) = 2{\cdot}84$; Ability to Memorize, $F(3, 18) = 1{\cdot}65$; Amount of Practice, $F(3, 18) = 1{\cdot}39$; Effectiveness of Practice, $F(3, 18) = 0{\cdot}65$; Self-discipline, $F(3, 18) = 1{\cdot}49$; Persistence, $F(3, 18) = 1{\cdot}75$; Speed of Learning, $F(3, 18) = 0{\cdot}36$; Eagerness to Play the Piano, $F(3, 18) = 2{\cdot}67$). The lack of between-level differences in terms of these 12

Table 3. Means and standard deviations (SD) for the teacher evaluation scores for each of the 12 aspects of skill

	Level 1	Level 2	Level 3	Level 4
Overall ability	3·80	3·83	4·67	4·80
SD	1·30	0·41	1·03	0·84
Natural ability	4·00	4·00	5·17	4·60
SD	1·22	0·63	0·98	1·14
Musicality	4·40	4·00	5·33	4·80
SD	1·14	0·63	0·82	0·43
Technique	4·20	3·33	4·17	4·80
SD	1·10	0·52	1·47	1·10
Aural ability	4·40	3·83	5·17	5·20
SD	1·14	0·75	0·75	1·10
Ability to memorize	4·60	4·33	5·33	4·00
SD	0·89	1·37	0·82	1·00
Amount of practice	4·40	3·50	4·83	5·00
SD	1·34	1·38	1·47	1·22
Effectiveness of practice	4·60	3·67	4·67	4·80
SD	0·89	1·75	1·97	1·10
Self-discipline	4·80	3·67	5·00	5·20
SD	0·84	1·75	1·55	0·84
Persistence	4·60	3·67	4·50	5·80
SD	1·14	1·75	2·07	0·45
Speed of learning	4·20	4·00	4·50	4·60
SD	1·30	0·63	0·84	1·52
Eagerness to play the piano	5·00	4·33	5·50	5·80
SD	1·00	1·37	0·55	0·45

aspects also suggests that the levels differed primarily with respect to musical skill at performing, as intended by the Associated Board in their grade examinations and by the classification system devised for this study. Although these analyses do not rule out the possibility that substantial individual differences may exist between the recruited musicians (both within and between levels), they do suggest that such differences, if they do exist, may be a result of the tasks required of this study (i.e. the learning, memorization and performance of an assigned composition).

Reliability of the performance evaluations

Judgments of musical performances are susceptible to subjectivity, prejudice and unreliability. To minimize such confounds, the standardized evaluation system set forth by the Associated Board of the Royal Schools of Music was adopted. In this system, musicians' abilities to perform set pieces, scales, arpeggios and sight reading are assessed by judges using a standardized list of requirements and scoring procedure. Table 4 lists the means and standard deviations of the scores on overall

Table 4. Means and standard deviations (SD) for the scores on overall quality, musical understanding, communicative ability and technical proficiency

	Level 1	Level 2	Level 3	Level 4
Evaluator 1				
Overall quality	6·40	6·00	7·50	4·60
SD	2·70	2·90	1·87	1·82
Musical understanding	6·60	5·50	8·00	5·40
SD	3·05	2·07	2·19	2·51
Communicative ability	6·20	5·17	7·67	4·60
SD	2·59	1·83	1·86	1·67
Technical proficiency	6·20	6·17	7·00	5·00
SD	1·79	3·43	2·19	1·00
Evaluator 2				
Overall quality	6·80	4·83	7·17	6·80
SD	2·58	2·23	2·93	3·27
Musical understanding	7·20	5·17	7·67	7·00
SD	2·77	1·60	2·94	3·00
Communicative ability	6·40	4·50	6·67	6·40
SD	3·36	2·07	3·33	3·44
Technical proficiency	6·00	4·83	6·50	6·20
SD	2·83	2·64	3·27	3·03
Evaluator 3				
Overall quality	5·40	4·33	6·83	7·40
SD	2·51	2·16	3·19	3·21
Musical understanding	6·00	4·50	7·00	8·60
SD	2·92	2·74	3·41	2·61
Communicative ability	5·00	4·00	7·17	7·40
SD	2·83	2·19	3·06	3·21
Technical proficiency	5·20	5·00	6·86	7·40
SD	1·64	2·68	2·99	2·88

Note. Performances were rated on a scale from 1 to 12.

quality, musical understanding, communicative ability and technical proficiency provided by each evaluator at Levels 1, 2, 3 and 4.

To test the reliability of the scoring, the evaluators' marks on overall quality were compared using Pearson correlations. Scores for overall quality were significantly correlated between all examiners (Evaluators 1 and 2: $r = {\cdot}68, p < {\cdot}01$; Evaluators 2 and 3: $r = {\cdot}84, p < {\cdot}01$; Evaluators 1 and 3: $r = {\cdot}53, p < {\cdot}05$). In an additional test of reliability, the evaluators' marks on overall quality were compard at each ability level using a repeated measures ANOVA, with mean ratings of overall performance quality as the dependent variable and evaluator as the independent variable. The results showed no significant effect on overall quality of evaluator ($F(2, 6) = 0{\cdot}57$, $p > {\cdot}05$) or ability level ($F(3, 18) = 0{\cdot}71$, $p > {\cdot}05$) and no significant interaction between evaluator and level ($F(2, 36) = 1{\cdot}50$, $p > {\cdot}05$). These findings suggest that the three examiners were reliable in their scoring.

Quantity of practice

Values for the quantity of practice were obtained from each pianist's cumulative records. These values included such aspects as the total time spent practising, the frequency of practice and the distribution of practice. Means and standard deviations for these values were calculated for each level of ability and are listed in Table 5.

Table 5. Means and standard deviations (SD) for the observed values of quantity of practice

	Level 1	Level 2	Level 3	Level 4
Total time				
Total time (minutes)	220·66	562·27	436·28	829·80
SD	86·71	118·47	265·81	507·98
Time per beat (minutes)	4·60	6·39	3·83	3·73
SD	1·81	1·35	2·33	1·93
Number of days	69·75	90·83	80·60	133·20
SD	17·00	35·67	55·65	61·57
Frequency				
Number of PS	33·61	41·44	22·35	28·21
SD	14·34	11·42	12·34	21·85
PS per day	0·51	0·57	0·47	0·27
SD	0·26	0·38	0·39	0·21
Distribution				
PSTime (minutes)	7·34	14·50	19·58	32·18
SD	3·89	5·30	6·46	12·16
$\sqrt{\text{PSTime}}$	2·62	3·76	4·37	5·59
SD	0·78	0·66	0·73	1·05

Key. PS = Practice session.

Total time was measured in two ways: (1) the total number of minutes spent practising and (2) the number of days encompassed within the entire learning process, from the first practice session up to the final performance. To eliminate possible effects of the length of piece being learned and to enable comparisons between levels of ability, the total number of minutes spent practising was divided by the number of beats in the corresponding piece to produce the mean time per beat across the entire learning process. The frequency of practice was measured in two ways: (1) the number of practice sessions in the entire learning process and (2) the average number of practice sessions per day. The distribution of practice was measured by the amount of time spent in each practice session (PSTime). Preliminary inspection of PSTime revealed that the data failed to pass tests of homogeneity (Levine Statistic $(3, 18) = 5{\cdot}88$, $p < {\cdot}01$). A further examination revealed that the values did not meet the assumptions of the normal distribution in that the data were positively skewed, with the standard deviations systematically increasing as ability level increased. Subsequent transformations of the scores revealed that a square root conversion ($\sqrt{\text{PSTime}}$) best satisfied the requirements of the normal distribution.

Each of the above values for quantity of practice was separately analysed using a one-way analysis of covariance (ANCOVA), with the respective measure as the dependent variable, level of ability as the independent variable and age as the covariate. Planned orthogonal contrasts were also performed to pinpoint specific differences between the levels of ability. Specifically, those contrasts were as follows: (1) Levels 1 and 2 vs. Levels 3 and 4, (2) Level 1 vs. Level 2 and (3) Level 3 vs. Level 4. Analyses of the values describing the total time spent practising and the frequency of practice revealed that those dependent variables did not differ significantly between ability levels, either in terms of the overall main effect or planned contrasts ($p > {\cdot}05$ for each of the following: Total Time, $F(3, 17) = 1{\cdot}65$; Time per Beat, $F(3, 17) = 2{\cdot}43$; Number of Days, $F(3, 15) = 0{\cdot}16$; Number of Practice Sessions, $F(3, 17) = 1{\cdot}80$; Practice Sessions per Day, $F(3, 15) = {\cdot}10$). Analyses of $\sqrt{\text{PSTime}}$, however, indicated a significant main effect of level of ability ($F(3, 17) = 6{\cdot}72, p < {\cdot}005$) with the dependent variable increasing with ability level. The planned contrasts revealed that $\sqrt{\text{PSTime}}$ was significantly greater for Levels 3 and 4 than for Levels 1 and 2 ($t(17) = 3{\cdot}80, p < {\cdot}005$) and Level 2 than for Level 1 ($t(17) = 2{\cdot}44, p < {\cdot}05$). Level 4 was not significantly greater than Level 3. Figure 2 displays mean values for $\sqrt{\text{PSTime}}$ at each level of ability.

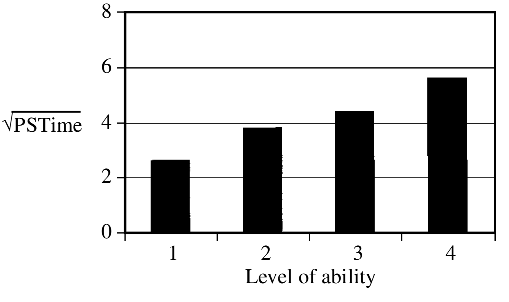

Figure 2. Mean values of the square root of practice session time ($\sqrt{\text{PSTime}}$) for each level of ability.

Table 6. Partial correlations between values for quantity of practice and ratings of pianists' performances, controlling for ability level

	Overall quality	Musical understanding	Communicative ability	Technical proficiency
Time per beat	·15	·08	·10	·16
Number of days	−·10	−·01	−·11	−·09
Number of PS	·04	·08	·07	·04
PS per day	·04	·03	·07	·01
$\sqrt{\text{PSTime}}$	·05	−·10	−·06	·03

Key. PS = Practice session.

Quantity of practice and quality of performance

Relations between the quantity of practice and quality of performance were investigated by examining partial correlations between measures of quantity of practice and mean ratings across the three examiners for overall quality, musical understanding, communicative ability and technical proficiency. Considering the small number of pianists in each level of ability, a level-by-level examination of these relationships was not possible. Consequently, ability level was controlled for in the partial correlations. As can be seen from Table 6, none of the correlations were significant.

Re-evaluating quantity of practice and quality of performance

A practice segment refers to the amount of music (i.e. the number of bars in a given composition) that a musician executes in one attempt, without stopping to correct mistakes. The size of practice segments provides a unique measure of the fluency of musicians' practice. Musicians, for instance, who are forced to correct many errors in their practice will, on average, stop more frequently to correct those errors and, thus, have shorter practice segments. Conversely, those who have fewer errors will be able to play through the composition more fluently and employ longer practice segments. To achieve such fluency, those musicians would have needed to overcome the basic, technical demands of a piece. Based on this idea, one may suggest that they would be freer to develop, implement and refine their musical ideas and the ways in which those ideas are communicated to audiences. Hence, accumulating more of this type of practice should enhance the quality of performance.

To test this hypothesis, mean values for the size of practice segments were obtained for each pianist across three stages in the practice process. Stage 1 included values for each pianist's first three practice sessions; Stage 2 included values for the middle three practice sessions; Stage 3 included values for the last three practice sessions. Three stages, spread evenly across the practice process, were chosen to provide comparable extracts from each pianist's practice. Three sessions were included in each stage to permit the maximum number of sessions per stage without exceeding the total number of sessions elicited by any participant (e.g. one Level 4 pianist practised for 14 sessions only). Considering that the length of each assigned composition at its respective level of ability was different, the values for segment length at each stage of practice were divided by the total number of bars in the corresponding composition to produce the 'proportion of the piece played' (see Table 7).

The calculated means for these values were examined at each level of ability to determine how they might have affected quality of performance. The resulting partial correlations (controlling for ability level) between the proportion of the piece played at Stages 1, 2 and 3 and quality of performance are listed in Table 8. The analyses indicate that this proportion was significantly correlated with overall performance quality, musical understanding, communicative ability and technical proficiency for Stage 2 of musicians' practice ($r = {\cdot}57$, $p < {\cdot}01$; $r = {\cdot}58$, $p < {\cdot}01$; $r = {\cdot}60$, $p < {\cdot}01$;

Table 7. Means and standard deviations (SD) for proportion of the piece played at Stages 1, 2 and 3

	Level 1	Level 2	Level 3	Level 4
Stage 1	·12	·05	·06	·06
SD	·02	·02	·06	·03
Stage 2	·22	·10	·16	·13
SD	·11	·02	·10	·10
Stage 3	·43	·22	·20	·30
SD	·10	·10	·05	·13

Note. Stage 1 included values for each pianist's first three practice sessions; Stage 2 for the middle three practice sessions; Stage 3 for the last three practice sessions.

Table 8. Partial correlations between proportion of the piece played at Stages 1, 2 and 3 and ratings of pianists' performances, controlling for ability level

	Overall quality	Musical understanding	Communicative ability	Technical proficiency
Stage 1	·03	·13	·03	−·08
Stage 2	·57**	·58**	·60**	·47*
Stage 3	·18	·16	·19	·15

* Correlation is significant at the ·05 level (2-tailed).
** Correlation is significant at the ·01 level (2-tailed).

and $r = {\cdot}47$, $p < {\cdot}05$, respectively). No other significant correlations emerged for either Stage 1 or 3.

Discussion

Quantity of practice

The analyses of total time and frequency of practice prove useful for further validating aspects of the implemented methodology. The four pieces in this study were specifically chosen for consistency of composer, style and length. Furthermore, they were selected to present somewhat equal challenges for the pianists at each level of ability. Clearly, no two compositions, even if written by the same composer, will present the exact same demands on skill. Yet, the lack of significant differences between levels of ability in terms of the total amount of time spent practising and the frequency of practice suggest that the compositions chosen were appropriate to and comparable across ability levels.

Before discussing the significant differences between levels with respect to the distribution of practice, some effort must be directed towards explaining why PSTime failed to pass tests of homogeneity. Inspections of the values for PSTime (see Table 5) revealed systematic increases in standard deviations from Level 1 to 4, indicating that the amount of time devoted to each practice session varied increasingly for the more skilled performers. This increase may be explained by considering the extent to which performers acquire explicit knowledge of their own strengths and weaknesses over the course of their training and tuition. Highly skilled performers, for example, may realize the need to improve one or more particular aspects of a specific composition and may determine the length of their practice based on how quickly they can address those aspects. Conversely, a group of novices may spend roughly the same amount of time in each practice session because their knowledge of their own strengths and weaknesses is not as elaborately developed or because they lack experience in honing practice to exploit their strengths and address their weaknesses.

Despite the finding that the standard deviations systematically increased from Level 1 to 4, analyses of $\sqrt{\text{PSTime}}$ revealed that the pianists at higher levels distributed their practice into longer practice sessions. This difference was large, even with such small sample sizes. Previous studies have revealed similar findings (see Ericsson *et al*., 1993, and Sloboda *et al*., 1996); however, these researchers have neglected to explain how and why highly skilled musicians sustain their practice over longer periods. At first glance, one may propose that, since such performers tend to be older than their lesser skilled counterparts, their ability and desire to sustain practice for longer periods is a direct function of age. Consequently, increased levels of maturity, patience and determination might permit them to engage in sustained practice. The findings of this study do not support this proposition. The levels of ability differed significantly in terms of the distribution of practice, even with age as a covariate.

A second plausible answer may be that highly skilled performers have developed more physical stamina for practice over years of experience. As a result, they are more adept at coping with the physical demands of practice and, thus, can spend more time on such activities. Indeed, research in motor-skill domains (e.g. sports, ballet and gymnastics) has revealed that changes in human anatomy—including musculature, bone structure, circulation and the respiratory system—result from continuous exposure to the physical demands of extensive practice (see Ericsson & Smith, 1991). Not all demands of practice, however, are physical. Musicians at all ability levels must respond to intense and multi-faceted requirements on cognitive, perceptual and motor skills during practice and performance. In terms of sheer execution, they must play the appropriate pitches, apply corresponding rhythms and articulations to those pitches, and adhere to suitable dynamic levels and tempi. Moreover, they must often acknowledge and communicate important musical structures (e.g. melodic and harmonic components); establish acceptable, or possibly novel, interpretations of the music; consider the environment in which a performance will occur; recognize the abilities, temperaments and ideas of colleagues with whom they perform; and retrieve vast amounts of material from memory.

As some elements of practice become automated, the number of cognitive, perceptual and physical activities with which performers can cope increases and the focus of attention changes (Kahneman & Chajczyk, 1983; Shiffrin & Schneider, 1977). Consequently, practice may become more enjoyable as individuals set and achieve goals that are relevant for success in their domain. Individuals at lower levels of ability, however, must often focus their attention on a narrow range of components (e.g. mastering technical difficulties). Focusing on such tedious aspects of skill can be monotonous and taxing, especially for those performers who do not have enough experience to see through the cloud of tedium to the rewards of performance.

Evidence from the pianists' comments during practice (recorded on cassette tape) and in subsequent interviews supports this interpretation of the empirical findings. Pianists at Levels 3 and 4 commented regularly during practice on a wide variety of issues, ranging from demands on physical coordination to the development and communication of novel interpretations of the music. One pianist at Level 3, for example, commented in an early practice session that she planned to work on fingerings used in various parts of the score. After isolating certain bars, she went on to remark that she needed to make her playing 'sound less like a machine'. Finally, at the end of the same session, she rehearsed bits of the score 'from memory'. Another example comes from one of the later practice sessions of a pianist at Level 4. She indicated that she wanted to set the tone for the Prelude by 'playing the first two quavers [i.e. eighth notes] short, detached and with spirit'. Shortly afterwards, she focused on technical problems that persisted in the middle of the composition. Finally, she ran through the piece five consecutive times, as if she were giving five consecutive performances. Such variety in practice was common and consistent for all pianists at Levels 3 and 4, both within each practice session and across the entire learning process. Comments by pianists at Levels 1 and 2, by contrast, centred primarily around the difficulties associated with the physical execution of the notes in the score (e.g. the fingerings used, coordinating the right hand with the left and playing difficult rhythms), not only for entire practice sessions but often throughout the course of the learning process. Still, the results of the planned orthogonal contrasts reveal that increases in physical and cognitive stamina for deliberate practice do not continue indefinitely with each increase in ability level. The greatest strides in acquiring increased levels of stamina—and possibly enjoyment—for practice appear to occur across the lower levels of ability and then become asymptotic.

Predictors of performance quality

The findings of this study do not confirm the prediction that quantity of deliberate practice is significantly correlated to quality of performance and, hence, go against the monotonic benefits assumption, which asserts that overall level of skill is determined by the amount of time an individual is engaged in deliberate practice. Do these results nullify the monotonic benefits assumption? Although, no researcher—or musician for that matter—would deny the importance of accumulating years of deliberate practice in achieving expertise, these results demonstrate that the relationship between quantity and quality is not as robust for situations in which performers are preparing for a specific performance. If quantity had been monotonically related to quality, significant correlations would have emerged. This did not occur, showing that amassing large quantities of practice provided few benefits for performers—musically, communicatively or technically.

Research by O'Neill (1997), however, did show a strong relationship between amount of piece-specific practice and performance outcome for a group of beginning musicians with up to 6 months of musical experience. These findings are in accordance with research on skill acquisition (see Fitts & Posner, 1967), but the Power Law of Practice does not necessarily describe the relationship between practice and performance for more experienced musicians. Compared with O'Neill's participants, the pianists in this study were, indeed, more experienced. Even those in Level 1 averaged 3·45 years of formal training on the piano by the start of the study.

The correlations between quantity of practice and quality of performance failed to reach significance, even when controlling for possible effects of level. Considering the strength of the relationship between quantity of deliberate practice and overall level of achievement in studies by Ericsson *et al*. (1993) and Sloboda *et al*. (1996), the failure to show the same relationship for the practice accumulated for specific performances is surprising. This may be explained by evaluating reasons why some performers devote more time than others when preparing for performance. Individuals who accumulate many hours of practice while learning a composition may spend that time achieving technical fluency in executing note-to-note detail, developing novel musical interpretations or refining methods of communicating their musical ideas. Performances that follow such practice will stand an excellent chance of meeting or surpassing the expectations of audiences. Conversely, others may accumulate many hours of practice simply because they have difficulties in overcoming technical inadequacies. Therefore, they accumulate lots of practice so that they can avoid error-riddled performances and fulfil the most basic expectation of audiences—the fluent, continuous execution of the entire composition.

As for why performers spend less time practising, some may achieve technical fluency in the early stages of practice, shifting their focus quickly to the enhancement of musical and communicative elements of performance. These individuals may have accumulated relatively few hours of practice across the entire learning process, but that practice would have been extremely efficient and productive. Others may struggle with technical inadequacies—like those mentioned above—yet fail to devote the time needed to overcome those inadequacies, possibly for lack of interest, other commitments, an abundance of frustration or failure to experience the rewards of performance. The resulting performances will almost certainly be unsatisfactory. This may have been the case for members of Group 5 in Sloboda *et al*.'s (1996) study who practised deliberately but withdrew from musical performance.

Ericsson *et al*.'s (1993) definition of deliberate practice appears to be too global. It simply does not account for possible differences in the content and quality of each performer's deliberate practice. As suggested by the analyses of the distribution of practice, such content has the potential to vary considerably, especially for those pianists at the highest levels of skill. Although previous researchers (e.g. Sloboda *et al*., 1996) have acknowledged the importance of examining the content of practice, none have collected data to permit such investigations. Some indication of the content of practice was obtained in this study by evaluating the size of practice segments. Results showed that pianists who employed longer practice segments by the middle stage of practice (i.e. the middle three practice sessions) produced better musical, communicative and technical performances. Their implementation of longer practice segments by this stage suggests that they had overcome the difficulties of the note-to-note execution of the composition and were in a better position to implement and refine their own musical and communicative ideas for performance.

Why was the second stage of practice so important for determining the quality of performance? Evidence obtained from interviews indicates that many of the pianists, during the first three practice sessions (Stage 1), were occupied by overcoming the sheer technical difficulties of the piece, learning to execute the notes at the written tempo and dynamic level. By the last three practice sessions (Stage 3), the pianists were anticipating the upcoming performance or practising performing from memory and, on average, employed longer practice segments. A pianist at Level 1, for example, remarked that she spent the majority of the first few practice sessions simply 'learning how to play the rhythms for the right hand in bars 1, 5, 6 and 10 and the notes for the left hand across bars 7–9'. Just prior to performance, however, she remarked that she was determined to 'play the whole piece by heart at least five times in a row without any mistakes'. Likewise, a pianist at Level 4 commented that she 'needed to spend a lot of time in the beginning trying to figure out the best fingerings to use. This meant practising specific bars over and over again.' By the end of learning process, she too was practising the entire composition to ensure that 'it flowed from the first bar to the last'.

Two questions emerge from these findings. First, do the obtained values for proportion of the piece played at Stages 1, 2 and 3 offer the most precise measurement of the moment at which performers begin to employ longer practice segments? Findings presented by Miklaszewski (1989, 1995) indicate that there is no precise moment at which performers switch from short to long practice segments. Both exist at all stages of practice, even in the earliest stages and the practice sessions just prior to performance. Therefore, the three discrete stages chosen for this study were selected to provide some indication of large-scale changes in this variable across the practice process. Second, although pianists who employed longer practice segments by Stage 2 produced better musical, communicative and technical performances, is there any evidence to suggest that the pianists specifically intended to adopt longer practice segments to improve these performance aspects? The proportion of the piece played at any given stage of practice is, no doubt, a crude measure for determining performers' intentions during practice. Those pianists who produced better performances may have begun formulating their musical, communicative and technical ideas well before Stage 2. Nonetheless, the findings suggest that pianists who produced higher quality performances may have been in a better position to implement some of those ideas by Stage 2.

Further evaluations of the content of practice are likely to reveal more precise relationships between quantity and quality. Moreover, expanding these evaluations to include many performers at different levels of ability may permit a level-by-level examination of the most important precursors to achieving expertise. The small number of participants in each level of this study precluded such examinations. Existing work by Williamon (1999) has examined the relationship between several such features and performance quality. He found, for example, that musicians who made concerted efforts earlier in the practice process to (1) mix isolated practice on selected portions of a score with run-throughs of the entire composition, (2) use musical 'structure' to guide the encoding and retrieval of musical information during practice and performance—especially practising from memory, (3) limit errors only to the most 'difficult' bars in a composition and (4) correct their errors, received higher ratings on performance quality.

Summary and conclusions

The findings of this study indicate that the content and quality of deliberate practice must be examined before fully understanding the factors which affect the quality of specific performances. But what role does the content of practice play in determining overall levels of skill? Ericsson *et al*. (1993) argue that expertise arises from the accumulation of effortful practice across several years. Nevertheless, to suggest that the accumulation of deliberate practice over several years is the fundamental precursor to expert-level performance seems paradoxical when considering that (1) the ability to produce outstanding performances on specific occasions is a major hallmark of expertise and (2) the monotonic benefits assumption fails to account for how such performances are produced. Even the data from their own study cannot fully be explained by the monotonic benefits assumption. The 'best' and 'good' violinists from Study 1, for example, differed in overall levels of skill, although many quantitative aspects of their practice (e.g. amount of practice alone, total amount of practice and amount of napping) were virtually indistinguishable.

To catalogue the exact determinants of overall levels of skill based on the findings of this study would mean going beyond the scope of the collected data. Still, the data indicate that further investigations of the content of deliberate practice must be completed before such determinants can be identified. These investigations should attempt to reveal the factors that influence the content of performers' practice and the extent to which such content is individual-specific. By doing so, additional evidence can be procured so as to address the unresolved nature/nurture debate over exceptional ability. Some researchers (e.g. Hepper, 1991; Howe, Davidson, & Sloboda, 1998; Parncutt, 1993; Sosniak, 1985) argue against the notions of 'natural ability' and 'innate talent' (see Wilding & Valentine, 1997; Winner, 1996), and they proffer that 'early experiences, preferences, opportunities, habits, training, and practice are the real determinants of excellence' (Howe *et al*., 1998, p. 399). They do not, however, have sufficient evidence to suggest exactly how individuals arrive at their preferences, make the most of their opportunities, decide upon and keep specific habits and individualize their training and practice. Moreover, they do not offer an explanation of why some individuals choose not to engage in deliberate practice—as with the group of music students in Sloboda *et al*.'s (1996) study who practised less than the other musicians and who subsequently gave up musical performance. Clearly, researchers must look beyond the quantity of practice when elucidating the acquisition of skills required for expert levels of performance.

Acknowledgements

The research presented in this paper was partially funded by the Overseas Research Students Award Scheme (Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom) and the Rotary Ambassadorial Scholarship. The authors gratefully acknowledge the help and cooperation of several individuals—Roger Chaffin, Gabriela Imreh and Carola Grindea for guidance in the early stages of this work; the participating pianists; and the participating piano teachers, Florence Creighton, Elaine Goodman, Heli Ignatius-Fleet, Nadia Lasserson, Murial Levin and Danielle Salamon.

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Received 4 March 1999; revised version received 11 November 1999