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It's Not How Much; It's How

Characteristics of Practice Behavior and Retention of Performance Skills

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We observed 17 graduate and advanced-undergraduate piano majors practicing a difficult, three-measure keyboard passage from a Shostakovich concerto. Participants' instructions were to practice until they were confident they could play the passage accurately at a prescribed tempo in a retention test session the following day. We analyzed the practice behaviors of each pianist in terms of numeric and nonnumeric descriptors and ranked the pianists according to the overall performance quality of their retention tests. Results indicated no significant relationship between the rankings of pianists' retention test performances and any of the following variables: practice time, number of total practice trials, and number of complete practice trials. There were significant relationships between retention test rankings and the percentage of all performance trials that were performed correctly, $r = –.51$, the percentage of complete performance trials that were performed correctly, $r = –.71$, and the number of trials performed incorrectly during practice, $r = .48$. The results showed that the strategies employed during practice were more determinative of performance quality at retention than was how much or how long the pianists practiced, a finding consistent with the results of related research.

Keywords: *motor skill learning; music learning; practice*

Tens of thousands of hours in musicians' professional lives are devoted to individual practice, the mechanism through which music skills are learned, refined, and maintained (Davidson, Howe, & Sloboda, 1997; Ericsson, 1997; Ericsson, Krampe, & Tesch-Römer, 1993; Howe, Davidson, & Sloboda, 1998; Madsen, 2004). Although this private aspect of musicianship is invisible to most nonmusicians, who typically hear only public performances, musicians are well aware of the centrality of practice in their life's work.

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Much of the extant research about music practice comprises comparisons among practice interventions or imposed strategies, testing the relative efficacy of modeling (Henley, 2001; Hewitt, 2001; Rosenthal, 1984; Rosenthal, Wilson, Evans, & Greenwalt, 1988), mental practice (Coffman, 1990; Lim & Lippman, 1991; Ross, 1985; Rubin-Rabson, 1941a, 1941b, 1941c; Theiler & Lippman, 1995), practice reports (Wagner, 1975), and distraction indexes (Madsen & Geringer, 1981).

Only more recently have scholars begun to study in context and over time the content of expert musicians' practice (Chaffin & Imreh, 1997, 2001, 2002; Chaffin, Imreh, Lemieux, & Chen, 2003; Gruson, 1988; Maynard, 2006; Williamon, Valentine, & Valentine, 2002) and the practice of novices (McPherson, 2005; Rohwer & Polk, 2006). Williamon and Valentine (2000), for example, observed practice among pianists at four different skill levels and found that quality, not quantity, of practice predicted performance quality at all levels of skill. In her study of pianists' practice, Gruson (1988) reported that the single best predictor of skill level was the extent to which players repeated larger sections of music, rather than individual notes. McPherson (2005), whose 3-year investigation of 157 beginning instrumentalists is one of the most substantive to date, also noted that the strategies employed in young musicians' practice, not the amount of time devoted to practice, were the best predictors of achievement.

Irrespective of the pedagogical implications of the more recent studies of practice behavior, making practice assignments in terms of *time practiced* instead of *goals accomplished* remains one of the most curious and stubbornly persistent traditions in music pedagogy (Kostka, 2002). Music teachers more often ask students to record practice time than they ask them to record the achievement of practice goals (Barry & McArthur, 1994), which promotes the notion that all students need to practice a prescribed number of minutes each day, regardless of how long it takes individuals to accomplish what they set out to do (Duke, Flowers, & Wolfe, 1997). In fact, informal reviews of private teachers' instructions for practice reveal that teachers commonly assign only what to practice and how long to practice, with little attention given to specific proximal goals to be accomplished each day. This is in stark contrast to assignments in many academic disciplines in school, where students are given sets of problems to solve, chapters to read, or essays to write, and the time devoted to homework is determined by the time required to complete the problems, read the chapters, or compose the essays. It seems readily accepted in other disciplines by teachers and students alike that all students will not devote the same amount of time to assignments, because individual learners work at different rates and different learners will not require the same amount of time to complete each assignment. How long one works depends on how long it takes to accomplish the assigned goals.

Although similar individual variations exist in the time required to accomplish performance goals in music, setting daily goals according to time spent seems to have become an accepted convention in planning music practice, most noticeably

among developing musicians. This is perhaps because of the notion that setting a routine for practice develops habits of consistent effort or because of the belief that daily repetition will inevitably lead advantageously to automaticity of motor skills. But, if the efforts made in practice are generally ineffective in improving performance, it is understandable that some learners conclude that their limited accomplishment is not worth the time invested.

There have been few studies to date in which skilled performers' practice behaviors have been observed in detail, the work of Chaffin and colleagues being the most obvious exception. The reasons for this are understandable, because the challenges of assessing practice behavior in a way that is systematic yet informative (beyond the measurement of discrete variables, such as time or duration of performance episodes) are daunting, to say the least.

The purpose of this study was to test the extent to which the quality of advanced pianists' performances of a difficult passage approximately 24 hr after it was introduced could be predicted based on what the pianists did during practice on the passage. We also set out to describe practice behaviors of the most effective learners in our sample.

Method

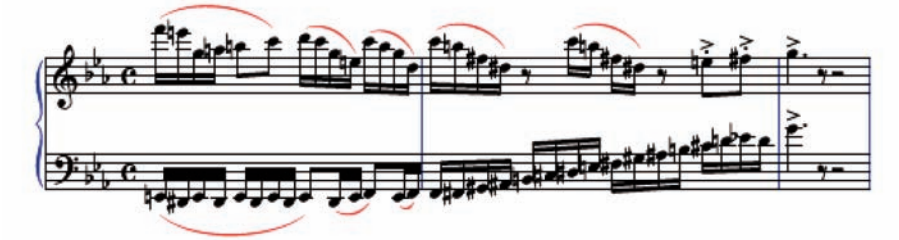
Participants were 17 graduate and advanced-undergraduate piano majors enrolled in piano performance and piano pedagogy degree programs in the Sarah and Ernest Butler School of Music at The University of Texas at Austin. We were able to identify 17 pianists who were willing to complete the research sessions.

Participants learned to play a three-measure passage from Dmitri Shostakovich's *Concerto No. 1 for Piano, Trumpet and String Orchestra, Op. 35* on a Yamaha Disklavier acoustic piano (see Figure 1). We chose the excerpt on the basis of its difficulty and accessibility—although it presents a number of technical challenges to the pianist and is quite difficult to sightread at tempo, it can be learned within a single practice session.

Upon arrival at the test location, participants were given approximately 2 min to warm up in whatever manner they wished. At the conclusion of the warm-up period, they were given a printed copy of the test excerpt (marked with their participant number), an electronic metronome, and a pencil. The following instructions were read aloud by the proctor, who remained in the room throughout all practice and test periods:

> Practice this excerpt until you feel that you have learned it well and can play it confidently at the target tempo (120 bpm) without the metronome. Take as much time as you need. A pencil and metronome have been provided if you wish to use them during practice. When you return tomorrow, you will play this excerpt again. The purpose of this project is to describe the changes that occur in your playing of the excerpt between today and tomorrow.

Figure 1
Test Excerpt From Dmitri Shostakovich's *Concerto No. 1 for Piano, Trumpet and String Orchestra, Op. 35*



We permitted participants to practice for as long as they wished. There were no explicit instructions concerning use of the metronome and pencil given to participants at the start of the session, and no apparent patterns were observed in the use of these items. Some participants used the metronome intermittently throughout practice, whereas others used it only as they neared the end of practice. The majority of participants wrote several fingerings in their scores (mostly for left-hand passages), and only 3 of the 17 pianists made additional markings in their music (e.g., circling notes, fingerings, or challenging transition points). When participants indicated that they were confident they had learned the excerpt and that they could play the excerpt at the target tempo on the following day, the proctor collected the music and instructed the participants not to practice the excerpt (even from memory) before returning 24 hr later. (The participants reported that they complied with our request not to practice the passage.)

When participants returned the following day, they were read the following instructions:

> You have approximately 2 minutes to warm up as you wish. Please do not play any part of the excerpt you learned yesterday during the warm-up.

At the end of the warm-up period, participants were given the same copy of the music they had used during their practice session on the previous day. The following instructions were read:

> Play straight through this excerpt at the target tempo 15 times. Please do not stop during any of your performance trials.

The proctor then played the metronome at the target tempo until the participant began his or her first trial, at which time the metronome was turned off. The 15

performance trials were played in succession, separated by brief pauses whose duration were determined by the participants. We included 15 trials in the retention session to provide us with enough material to make reliable discriminations among the performers.

We recorded all practice and test sessions on digital videotape and recorded all MIDI data from the keyboard for subsequent analysis. In addition, we converted the MIDI signal from the retention test performances to QuickTime audio files for evaluation.

We observed all video recordings of the 17 participants' practice sessions and compiled the following numerical data from each session: total practice time, number of performance trials (the number of times the pianist began playing), number of complete performance trials (the number of hands-apart or hands-together performances of the entire excerpt), number of correct performance trials (complete performances of the entire excerpt at any tempo without error or hesitation), number of near-correct performance trials (complete performances of the entire excerpt at any tempo with only one or two minor errors or hesitations), the sum of correct and near-correct performance trials, number of incorrect performance trials (performances of the entire excerpt that contained errors), the percentage of complete trials that were correct (the proportion of performances of the entire excerpt that were without error or hesitation), the percentage of complete trials that were correct and near-correct (the proportion of performances of the entire excerpt that were without error or hesitation plus those with only one or two minor errors or hesitations), and the percentage of all trials (including incomplete trials) that were correct. From the retention tests, we recorded the number of trials out of 15 attempts that were correct, the number of trials that were near-correct, and the sum of the correct and near-correct trials. Note that the correct and near-correct trials in these analyses were defined only in terms of pitch and rhythm accuracy. Interjudge reliability for our assessments of correct and near-correct trials was .96.

After recording the numerical data, we observed the video recordings again in an effort to characterize further the features of each participant's practice procedures. We wrote explicit descriptions of the practice behaviors that appeared rather consistently throughout each participant's practice session. When there were discrepancies among our descriptions, we arrived at consensus after viewing the tapes together to clarify one another's observations. Thus, the descriptors of practice presented in Table 1 represent only those characteristics that were agreed upon by all three authors.

We independently ranked the audio recordings of the retention test performances, taking into account the tone, character, and expressiveness of the performances. This ranking procedure permitted a more encompassing evaluation of the retention test performances, beyond the simple counting of correct and near-correct trials. The 17 QuickTime audio files were assigned random ID numbers that differed from the sequential numbering of the practice videotapes and were placed in an otherwise-empty folder on an Apple Macintosh computer screen. Clicking on a given icon initiated playback of the participant's 15 retention test performances. We listened

individually to the recordings over high-quality loudspeakers. Our task was to rank the participants from best to worst in terms of overall performance quality across the 15 trials in the retention test. This procedure for evaluating multiple music performances proved quite advantageous, as it combined unlimited opportunities for rehearing, ease in hearing performances in juxtaposition, and the ability to order on the computer screen the icons representing the performers' retention tests. Agreement across our rankings was moderately high and certainly acceptable for the purposes of our investigation, Kendall's $W = 0.83$, $p < .001$.

Results

We report the characteristics of each participant's practice session in Table 1. Participants' data are ordered based on the mean of our rankings of the retention test performances, which are positively correlated, but not perfectly correlated, with the total number of correct and near-correct repetitions in the 15 retention test trials, $r = –.79$, $p < 001$. The size of this correlation (64% shared variance between rankings of overall performance quality and counts of correct and near-correct trials) provides some indication of the extent to which performance quality variables other than correct notes and rhythmic precision affected our ranking judgments.

We performed bivariate correlations between each of the variables in the table and the participants' rankings. These results are reported in the bottom row of Table 1. In addition to the understandably high correlation between the mean judge ranking and the sum of correct and near-correct trials in the retention test, there were significant correlations between the pianists' rankings and the following: the number of complete, incorrect performance trials, $r = .48$, $p = .05$; the percentage of all complete trials that were correct, $r = –.71$, $p = .001$; the percentage of complete trials that were correct and near-correct, $r = –.64$, $p = .006$; and the percentage of total performance trials (including incomplete trials) during practice that were correct, $r = –.51$, $p < .04$.

It seems equally important to point out the variables that were not related significantly to participants' retention test ranks: the total time practiced, $r = .18$, $p > .49$; the total number of performance trials, $r = .12$, $p > .65$; the total number of complete trials, $r = .02$, $p > .93$; and the total numbers of correct and near-correct trials, $r = –.15$, $p > .56$. This seems an indication that the nature of the practice defined in our observations was more determinative of retention test performance than was the amount of practice. We found that the three participants whose retention tests earned the highest ranks were clearly superior to the next-highest-ranked participants (data for those three participants appear above the line in the table). The retention test performances by these three pianists were distinguished from the performances of the other participants by a more consistently even tone, greater rhythmic precision, greater musical character (purposeful dynamic and rhythmic inflection), and a more fluid execution.

Table 1
Descriptive Data for Individual Participants, Rank-Ordered by Retention Test Performance Quality

			Practice Session									Retention Test (15 trials)			
Practice Characteristics	Degree	Rank	Time (in seconds)	Trials	Complete	Correct	Near-Correct	Correct + Near-Correct	Incorrect	% of Completed Correct	% of Completed Correct + Near-Correct	% of Total Correct	Correct	Near-Correct	Correct + Near-Correct
A B C D E F G H I J K	DMA	1	1400	288	81	59	16	75	6	.73	.93	.20	3	12	15
A B C D E F G H I J K	MM	2	1620	204	48	45	2	47	1	.94	.98	.22	7	5	12
A B C E F G H J K	DMA	3	711	116	48	28	11	39	9	.58	.81	.24	11	2	13
A C E F H J	MM	4	514	114	38	21	13	34	3	.55	.89	.18	5	6	11
A B J	DMA	5	530	113	27	14	12	26	1	.52	.96	.12	4	6	10
A B E F H J K	MM	6	556	110	34	28	6	34	0	.82	1.00	.25	4	7	11
A B F J K	MM	7	598	124	47	38	8	46	1	.81	.98	.31	3	7	10
A B E	BM (jr)	8	1146	339	27	15	9	24	3	.56	.89	.04	0	9	9
C E G	BM (jr)	9	2998	739	79	57	10	67	12	.72	.85	.08	0	9	9
A B C E	DMA	10	535	112	43	14	21	35	16	.33	.81	.13	10	3	13
A B C	DMA	11	678	111	24	3	18	21	3	.13	.88	.03	0	12	12
A B C	MM	12	1110	209	74	37	23	60	14	.50	.81	.18	3	7	10
C	BM (sr)	13	3410	689	114	2	80	82	32	.02	.72	.00	3	8	11
A B C D E K	BM (sr)	14	1520	225	100	63	32	95	5	.63	.95	.28	0	7	7
A E G	BM (jr)	15	538	82	31	15	11	26	5	.48	.84	.18	2	3	5
C	DMA	16	1590	226	40	0	11	11	29	.00	.28	.00	0	4	4
A B C	MM	17	887	160	13	0	7	7	6	.00	.54	.00	0	0	0
Correlation (r) with retention test rank		1.00	0.18	0.12	0.02	–0.44	0.31	–0.15	.48*	–.71**	–.64**	–.51*			–0.79**

Note: Reliability for judgments of ranking (three judges), $W = .83$; reliability for judgments of correct and near-correct trials (two judges), .96 agreements.
*$p < .05$. **$p < .01$.

This finding led us to begin our practice session observations with the sessions of these 3 pianists in an effort to identify the elements that best characterized their work. We reached consensus on the following eight elements, all of which except Item D below appeared in the 3 top-ranked pianists' practice sessions; Item D was in evidence in 2 of the top 3 pianists' sessions. Letter designations below correspond to those in Table 1. The combination of practice strategies that characterized the practice sessions of the top-ranked pianists was clearly absent in the sessions of the other pianists, although many of the 14 lower-ranked pianists included some of the strategies used by the top 3.

A. Playing was hands-together early in practice.
B. Practice was with inflection early on; the initial conceptualization of the music was with inflection.
C. Practice was thoughtful, as evidenced by silent pauses while looking at the music, singing/humming, making notes on the page, or expressing verbal "ah-ha"s.
D. Errors were preempted by stopping in anticipation of mistakes.
E. Errors were addressed immediately when they appeared.
F. The precise location and source of each error was identified accurately, rehearsed, and corrected.
G. Tempo of individual performance trials was varied systematically; logically understandable changes in tempo occurred between trials (slowed down enough; didn't speed up too much).
H. Target passages were repeated until the error was corrected and the passage was stabilized, as evidenced by the error's absence in subsequent trials.

The following three observations also were made based on the three top-ranked pianists' practice sessions. We list them separately here because they are not practice strategies but are nevertheless descriptive of the sessions we observed.

I. When tempo was changed, the first trial at the new tempo was nearly always accurate.
J. After the initial learning phase, errors were only intermittent; there were no persistent errors.
K. At least 20% of all starts were complete, correct performances, although not necessarily at the target tempo of 120 bpm.

Discussion

Our data describe the practice behaviors of multiple, advanced-level performers learning the same excerpt. This is one of the few reported examples of research that defines the characteristics of effective practice based on the observed behaviors of multiple advanced performers with varied levels of practice skill. Our findings illuminate some of the important aspects of practice that differentiate more and less able practicers, as determined by their performances 24 hr after practice.

Our results show that, among our sample of performers, the strategies employed during practice were more determinative of their retention test performances than was how much or how long they practiced. It seems particularly notable that total time and total number of performance trials were unrelated to the quality of the retention test performances and that the best-performing pianists took no less time to learn the passage than did the other pianists. This seems to contravene the notion that the pianists who performed best on the retention test were able to learn the passage more quickly and more easily than the others. A more accurate summary of what took place is that the top-ranked pianists learned the excerpt differently from the other pianists.

The most notable differences between the practice sessions of the top-ranked pianists and the remaining participants are related to their handling of errors. The observations labeled F, G, and H in Table 1 were present in the sessions of all three of the top-ranked pianists, but they appeared in few of the other pianists' practice sessions (none of the other pianists demonstrated all three of these characteristics). The three characteristics are as follows:

F. The precise location and source of each error was identified accurately, rehearsed, and corrected.
G. Tempo of individual performance trials was varied systematically; logically understandable changes in tempo occurred between trials (slowed down enough; didn't speed up too much).
H. Target passages were repeated until the error was corrected and the passage was stabilized, as evidenced by the error's absence in subsequent trials.

Thus, it seems that the actions taken subsequent to the discovery of errors were major determinants of the effectiveness of practice. It was not the case that the top-ranked pianists made fewer errors at the beginning of their practice sessions than did the other pianists. But, when errors occurred, the top-ranked pianists seemed much better able to correct them in ways that precluded their recurrence. This is an extremely important point—that the effective handling of error correction led to a higher proportion of correct, complete performance trials during practice.

The most effective way that the participants corrected errors was by making judicious changes in performance speed that facilitated the maintenance of accuracy following the correction of a given error. Of course, there were other methods of decontextualization, in addition to tempo change, that appeared among the strategies employed by these performers (e.g., playing shorter passages, playing hands separately), but the method of varying tempos was a distinctive feature of the top-ranked pianists' approaches. In fact, two of the top-ranked pianists made alterations in their performance tempos that preempted errors before they occurred (labeled Item D in Table 1). In other words, after a given error was discovered, these two pianists tended to hesitate in subsequent trials as they approached the location of the error, often slowing the tempo (without stopping) to a point at which the playing could continue accurately past the location where the error had occurred in a preceding trial.

These results point to the importance of developing in young musicians effective approaches to correcting errors—procedures that preclude errors' persistence. Yet, it is rare in published methods to see examples of systematic instruction in problem solving and error correction, even though devising solutions to problems is one of the central features of learning. It is generally not the case that experts (in any discipline) simply avoid making mistakes when they are learning something new, but experts correct their mistakes efficiently and effectively. Thus, it seems that error correction should be a prominent part of novices' instruction and that the most appropriate goal for young learners is not that they play their instruments for 30 minutes a day but that they skillfully identify and systematically address the mistakes that are an inevitable part of learning.

It is understandable that many students of music are of the mind that their primary goal is to avoid making mistakes, and most young players are not privy to what goes on in experts' individual practice sessions, including their own teachers' practice sessions. These same students may come to believe that a major difference between them and their teachers is that their teachers seldom make mistakes at all, when in fact all learners, including experts, make mistakes as they take on new challenges, learn new repertoire, encounter new problems, and teach new students. Experienced musicians' expertise is characterized by their ability to deal with mistakes and solve knotty problems in ways that maximize efficiency and lead to lasting solutions.

There is no doubt that most students have heard their teachers demonstrate good playing, but it is probably also true that few have observed their teachers encountering performance problems and advantageously addressing them. If there is broad agreement that providing good models is an effective strategy for learning, then why are there so few available models of effective practice? It is clear that this question deserves considerable attention in the future.

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