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Analysis of Practice
by Novice Musicians in a Piano Class

Practice is the primary mechanism for developing musical skills, and in terms of time, it can be one of the most demanding aspects of a musician's daily routine. Despite the role it plays in musical development, individual practice is a largely independent component of traditional music instruction; music students are often told by their teachers what, when and how much to practice (Gaunt 2008, 237; Koopman et al. 2007, 383), but the act of practicing itself typically occurs outside of instruction and, thus, without supervision.

Observations of both novice and advanced musicians suggest that how an individual organizes their practice is associated with how that individual performs (Duke, Simmons and Cash 2009, 316–317; Ericsson, Krampe and Tesch-Römer 1993, 386–387; McPherson 2005, 23–25; Miksza 2007, 367; Pike 2017, 744–746; Williamon and Valentine 2000, 366–367). Duke and colleagues (2009, 316) observed that advanced musicians who were more successful in a short performance task practiced differently, but not necessarily more, than musicians who performed less successfully. This relationship between practice quality and performance quality has also been observed in less experienced populations: middle school students who used structured practice behaviors demonstrated better performance outcomes (Miksza 2007, 366–367), and undergraduate students who self-reported more practice time did not necessarily outperform peers who spent less time practicing (Burwell and Shipton 2011, 263).

Analyzing musicians' practice in relation to their performance ability has allowed researchers to define elements of effective practice. Namely, effective practice is characterized by both an individual's ability to set proximal goals that lead to their desired outcome and their ability to discern and adjust for discrepancies between their intentions and their actions when practicing (Hallam et al. 2012, 659, 665; Palese and Duke 2021, 5–7; How, Tan and Miksza 2022, 688–689). These qualities of expert practice distinguish it from less successful practice often demonstrated by novices, who may fail to organize their practice around achievable, clear goals (Pike 2017, 745–746). When individuals adjust their actions to consistently match their intentions during practice, they are more likely to reach their goals and experience lasting, positive changes in their performance (Ericsson, Krampe and Tesch-Römer 1993, 368, 386; Lehmann and Ericsson 1997, 44–47).

This definition of effective practice is based in foundational principles of motor skill learning and procedural memory formation. When an individual initiates an action, the brain launches a series of motor commands that lead to the execution of the desired action. Simultaneously, the brain creates an efference copy, which retrieves memories of the action's previous outcomes and, based on those memories, makes a prediction about the outcome of the upcoming action. When the action is executed, the efference copy (prediction) is compared to the actual outcome. If no discrepancies are perceived and the action's outcome matches the original prediction, no adjustments to the movement or procedural memory are made. If there are differences perceived between the outcome

and the prediction, the prediction error leads to an adjustment in the action's procedural memory (Kandel 2013, 1733–1734; Wolpert and Kawato 1998, 1318).

In learning contexts, this relationship between prediction and perception, known as a *forward model*, is a crucial part of error detection and self-monitoring (Wills et al. 2007, 850; 852). If learners do not have a clear prediction of what they are trying to accomplish, they will be unable to accurately evaluate their own progress and identify mistakes in their learning (McPherson et al. 2019, 25; Pike 2017, 745–746). However, when learners have clear, attainable intentions and awareness of their own actions, they can better adjust their behavior to meet their goals (Nielsen 2001, 159–160).

Case studies of expert music practice indicate that when experts practice, they organize their practice around small, achievable goals that eventually lead to long-term desired outcomes (Chaffin and Imreh 2001, 50–51, 57–58; 2002, 344–346; Ericsson, Krampe and Tesch-Römer 1993, 368, 386–387; Killion 2023, 14; Lehmann and Ericsson 1997, 47–49). While working toward these small, proximal goals, experts monitor their own behavior to adjust for moment-to-moment differences between their actions and their intentions (Killion 2023, 14). This monitoring allows experts to quickly perceive and correct errors in their playing (Chaffin and Imreh 2001, 58–62; 2002, 344–346; Duke, Simmons and Cash 2009, 316–317).

While this type of practice organization has been observed in successful student musicians, (McPherson et al. 2019, 27), many novice musicians often fail to exhibit this type of intent and self-awareness when they practice (Pike 2017, 745–746). The goals novices set can be overly broad (Oare 2012, 67) and are often related to accuracy and execution rather than expression and artistry, perhaps due to the number of attentional resources novices need to perform an action before reaching automaticity (Beilock et al. 2004, 375–376). In a study by Oare (2012, 65–69), middle and early high school students struggled to set well-identified goals, identify problems and maintain focus when practicing. Even when these students successfully identified an issue in their playing, their attempts to solve the problem using practice modifications were not effective. Pike (2017, 745) similarly observed that high school piano students were often distracted and tired during their practice sessions, which negatively impacted the effectiveness of their practice.

Despite these findings, the extent to which student musicians are taught explicitly how to practice is unclear. Case studies of undergraduate students indicate that little, if any, instructional time is dedicated to explicit practice instruction (Burwell and Shipton 2013, 336; Gaunt 2008, 237; Koopman et al. 2007, 384). Even students with multiple years of formal music instruction do not always know how to practice effectively (Burwell and Shipton 2013, 336–337; Koopman et al. 2007, 386; Pike 2017, 744–747). In an investigation of teacher and student attitudes about teaching and practice, Koopman and colleagues (2007, 383–386) observed that conservatory teachers often failed to give clear directives for how students should organize their independent practice, and even when clear directives were given, students' interpretations of those instructions during independent practice were not always aligned with the teacher's original intentions. This observation contrasted with how teachers in the study reported on practice instruction; teachers generally asserted that they clearly outlined how students should practice. This discrepancy between teachers' directions and students' interpretations concerning practicing was similarly observed in later research; in a study by Pike (2017, 743; 745), high school pianists, even when presented with practice instruction in the lesson, varied in their ability to practice according to their teacher's plan.

Understanding the challenges developing musicians face in the practice room is vitally important for teachers and students, because how students practice can predict their performance (Hallam et al. 2012, 660–668, 670–671; Williamon and Valentine 2000, 371–372). Practice and performance quality may improve when individuals adopt characteristics of effective practice. In a study by Barry (1992, 116–19) novices who organized their practice demonstrated increased

melodic accuracy, rhythmic accuracy and more effective musical expression; in a later study by Miksza and colleagues (2012, 261), intermediate students who self-monitored their behavior tended to stay on-task during practice. These improvements indicate practice effectiveness can be developed with deliberate effort and training.

The practice behavior of developing musicians has been observed primarily in younger populations, namely young children (McPherson 2005, 7–9), middle school students (Miksza 2007, 362; Miksza, Prichard and Sorbo 2012, 257) and adolescents (Palese and Duke 2021, 3; Pike 2017, 741–742). However, there remain a limited number of systematic observations examining how undergraduate and young adult novice musicians approach independent practice. The purpose of this study was to observe and analyze practice characteristics of novice musicians when learning a novel chord progression. Our research questions were: 1) How did novice undergraduate pianists practice when learning a novel chord progression? 2) Were there characteristics that distinguished the practice of the pianists who most successfully learned the given chord progression? 3) Were those practice characteristics consistent with previous observations of effective music practice in advanced pianists?

Method

Participants

Participants ($N = 23$) were undergraduate non-music majors at a large, Southwestern U.S. university. Participants were novice musicians enrolled in two sections of an introductory group piano course during the fall semester. At the time of data collection, which occurred at the end of the semester, they had had more than three months of instruction. The first author was the instructor for both class sections. We collected participant data as part of normal course activities. Demographic information about participants' age, degree program, year in school and previous musical experiences was not collected. Analysis of these data was approved by the Institutional Review Board of the authors' home institution.

Procedure

In the final week of the semester, we asked participants to learn a four-chord progression in C major (Figure 1). We provided written instructions, notation of the chord progression and a video model (side view of the performer) of the desired final product. The assigned goal was to perform the progression, hands together accurately and with inflection, at a tempo of quarter note = 120 beats per minute. We asked participants to make their performance as close as possible to the video model. Participants had received limited practice instruction over the course of the class, and participants were provided no instructions on how to practice the task. Participants submitted a 10-minute video of their individual music practice.

In this video, I'd like to observe you practicing one of your assignments. I'm most interested in watching and hearing what you do as you practice. I'm less interested in your final performance at the end of your practice session.

TASK:

Read the goal.

Watch the video model.

Record yourself practicing for 10 minutes. Your goal is to make your performance as close as you can to the model performance that I recorded in the video below. Even if you are unable to match the model exactly, please try to get as close as you can.

GOAL: To play through a 4-chord progression in closest position, hands together with ease and accuracy.

VIDEO MODEL: C, Dm, F, G7 progression

Progression: C, Dm, F, G7

Closest Position:

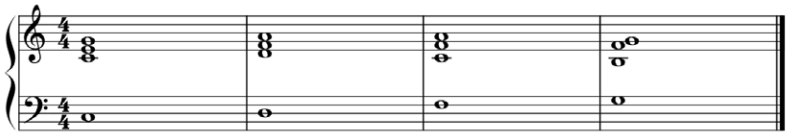

Figure 1: The prompt for the practice task.

Participants recorded their videos independently, using their own recording devices and either their own keyboards or pianos available on campus. After recording their videos, they uploaded the videos to YouTube and submitted the video link via the Canvas course website. Videos were then converted to local mp4 files for analysis.

Analysis

We watched each practice session in its entirety, then grouped participants into three categories (high, moderate and low success) according to how closely each participant's ultimate performance trials resembled the trials from the video model in terms of accuracy and fluency; this classification was based in part on a rationale used by Duke and colleagues (2009, 312–315) in their analysis of advanced pianists' practice.

We evaluated participants' success based on the best two trials performed during the last 45 seconds of their practice sessions. We classified a participant's performance as accurate if they played at least two note-perfect performance trials during the last 45 seconds of their practice. Performance trials that were note-perfect but under tempo were considered accurate, and performance trials that deviated by one or more notes from what was written in the practice task were considered inaccurate. We further classified a participant's performance as fluent if their two best trials were played close to the designated tempo (between 100–120 beats per minute), without visible tension in the hands or arms, and without hesitation between chords.

At the end of their practice session, participants in the "high success" group ($n = 3$) played the progression accurately and fluently; participants in the "moderate success" group ($n = 13$) played accurately or fluently, but not both; and participants in the "low success" group ($n = 7$) played the progression neither accurately nor fluently.

We used practice characteristics originally found in Duke and colleagues (2009, 317) to code the practice behavior of each participant. Although they found 11 total characteristics of practice behavior, we used the following 10 characteristics in our analysis.[1]

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 evidence by the error's absence in subsequent trials.
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.

We observed 9 of these 10 practice characteristics during the practice of these participants (characteristics A, C, D, E, F, G, H, I and J). Characteristic B (practicing with inflection) was absent from all participants' practice.

Participant ID	Achievement Group	Practice Characteristics								
9	High	A	C		E		G	H	I	J
15	High	A	C	D	E	F	G	H	I	J
20	High	A			E	F	G	H	I	J
3	Moderate	A	C	D	E		G			
5	Moderate	A	C	D	E	F	G			
8	Moderate	A					G			
10	Moderate	A		D			G	H		
12	Moderate		C	D			G			
13	Moderate	A	C	D			G		I	
14	Moderate	A	C				G			
16	Moderate	A	C	D						
17	Moderate	A	C	D			G			
19	Moderate	A		D			G			
21	Moderate	A		D			G			
23	Moderate	A	C	D						
24	Moderate	A	C	D			G			
2	Low	A	C	D			G			
4	Low	A	C				G			
6	Low		C				G			
7	Low	A	C				G			
11	Low	A	C				G			
18	Low			D			G			
22	Low		C	D						

Table 1: Practice Characteristics and Success Level of Novice Musicians in a Practice Task
Note: Letters refer to the characteristic observed during practice. Participants are labeled by subject number and are separated into groups according to their success in accomplishing the practice task.

Results

The most common characteristics across all participants were A (n = 19; hands together early in practice), C (n = 17; thoughtful practice), and G (n = 20; systematically varying tempo), and the least common behaviors were B (n = 0; practice was with inflection early on), F (n = 3; precise location and source of each error identified, rehearsed, corrected) and J (n = 3; after initial learning, errors were intermittent, not persistent). Mean practice durations were 10 minutes 27 seconds in the "high success" group, 10 minutes 58 second in the "moderate success" group, and 11 minutes 7 seconds in the "low success" group.

Participants in the "high success" group demonstrated a greater number of the 10 practice characteristics ($M = 7.67$, $SD = 1.15$) than did participants in the "moderate success" ($M = 3.70$, $SD = 1.11$) and "low success" groups ($M = 2.71$, $SD = .76$). All three participants in the "high success" group were the only participants to demonstrate characteristics H, I and J:

h. Target passages were repeated until the error was corrected, and the passage was stabilized, as evidence by the error's absence in subsequent trials.
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.

In Duke and colleagues' (2009, 316–317) original analysis, the two most successful participants were also the only ones who demonstrated characteristics H, I and J.

An independent observer (a music teacher and researcher) analyzed the data for reliability. They reviewed five videos, selected at random, and coded the behavior of each participant according to the coding scheme we had developed. There were 10 characteristics (characteristics A–J) that could potentially be observed in each participant's video. The first author and the independent observer agreed on 43 out of 50 potential characteristics across the five selected videos. Together the first author and the independent observer agreed on all 10 observed characteristics in two participants' practice, 8 of 10 characteristics in two participants' practice, and 7 of 10 characteristics in one participant's practice.

The independent observer additionally reviewed the performance trials in the last 45 seconds of each of the videos and classified participants as "high success," "moderate success" or "low success" based on the classification scheme we used. There were no discrepancies between the first author's classification and the independent observer's classification of each participant.

Discussion

The purpose of this study was to observe how novice pianists practiced when given a performance task and to investigate whether individuals who successfully completed the performance task practiced differently than did individuals who were not as successful. We sought to know how participants achieved what they were able to achieve, whether their performance was accurate and fluent or full of mistakes. What kind of practice led to an ideal result, and what kind of practice led to a less-than-optimal result? Our analysis suggests that differences in participants' practice effectiveness are consistent with differences in their performance quality, thus adding to a growing body of work that attributes an individual's performance skill partially to how they practice that skill. In short, the participants who were better at performing were also better at practicing.

The first author, who was also the course instructor, was surprised by the overall inefficiency of participants' practice behavior. Throughout the semester, most participants had performed well on homework assignments and, during class instruction, demonstrated high engagement in the subject matter and sufficient understanding of musical concepts. However, observing their practice revealed that their approaches to learning were often ineffective and overly time-consuming. By watching participants practice, the first author observed major shortcomings in their approaches to music learning that had not previously been apparent in their classwork.

Differences between the practice of participant groups were evident by observing how participants corrected mistakes during their session. This finding corroborates the conclusions of Duke and colleagues (2009, 316–317) and is similar to Miksza's (2007, 369) observations of a correlation between

performance achievement and individuals who isolated sections of music in their practice. One surprising observation was that participants across groups made similar modifications during their practice, regardless of their ultimate success in correcting errors and in the final performance. Repetition, playing hands separately and slow practice were used by most participants in all three groups; however, only three participants were able to successfully complete the performance task. Thus, an issue in novice practice may not be knowing *what* practice modifications to use, but *when* and *how* to use them to accomplish a goal, an issue similarly observed by Pike (2017, 745–746). The use of certain modifications during practice does not guarantee improved performance or development of expertise (Hallam et al. 2012, 669; Pike 2017, 745). Rather, performance achievement may be more closely related to an individual's ability to maintain accuracy and fluency during practice, regardless of what modifications they use.

When learning the progression, and upon making a mistake, participants in the "high success" group typically modified their playing so that they could play accurately, a characteristic similarly observed in the practice of expert musicians (Chaffin and Imreh 2001, 56; 2002, 344–346; Duke, Simmons, and Cash 2009, 316–317; Killion 2023, 14). Then, these participants repeated the newly learned or newly corrected section of music until it was stable and error-free, and by the end of their sessions, most performance trials were accurate and at tempo. In contrast, errors persisted until the very end of the practice sessions of the "moderate success" and "low success" groups. After making an error, these participants did not always modify their playing to correct the error, nor did they identify the precise location and source of each error. When the error was corrected, they tended to move on after only one or two accurate performance trials, and the error persisted in their playing. Problems identifying and correcting errors point to limitations in self-monitoring; it is obvious many participants did not have clear proximal goals for their practice, which would thus affect their ability to discern discrepancies and make relevant adjustments to their playing to compensate for errors (Wills et al. 2007, 850, 852; Wolpert and Kawato 1998, 1318).

All participants failed to incorporate musical inflection in their playing. Practice sessions were overwhelmingly focused on learning and playing the correct notes. This could in part be attributed to the keyboards many participants used for their session, which lack the musical sensitivity of an acoustic piano. The overall neglect of musical expression in their practice is a departure from the video model that was provided and from previous in-class instruction and supplemental materials, all of which included musical expression.

A particularly salient observation from our analysis was how long it took participants to achieve consistent accuracy and fluency during their recording. Two of "high success" participants (participants 15 and 20) learned the chord progression quickly; they were able to play the progression hands together without errors during the first 60 seconds of practice. Most of their session involved repeating the chord progression, presumably to gain fluency. In contrast, the third "high success" participant (participant 9) took more time to learn the progression (They did not play the progression in its entirety until more than halfway through the session.), learned the progression in small pieces and narrated their entire practice session. Though their approaches to learning the progression varied, all three "high success" participants ultimately played the progression accurately and fluently; however, only the slow, deliberate practice of participant 9 better resembles the intent and planning observed in expert practice (Chaffin and Imreh 2001, 50–51, 56–57; 2002, 348; Ericsson, Krampe and Tesch-Römer 1993, 386; Killion 2023, 14).

Applications to Music Teaching and Learning

Our study also offers practical insights for music teachers and learners. Learning to identify and correct errors independently may improve the practice effectiveness of music learners, particularly novices. Students who demonstrate successful, consistent error correction in their practice may also experience an increase in performance quality. Further, students should approach practice with deliberate care and planning. Practice that is rushed and careless can jeopardize performance quality, whereas organized practice tends to produce improved performance outcomes (Barry 1992, 116–119; Miksza, Prichard and Sorbo 2012, 261).

Teachers are encouraged to prescribe and supervise student practice to foster effective practicing early in a student's musical development. It may be advantageous for teachers to include practice as a topic of instruction during classes and lessons, even replicating features of this study to analyze the practice behavior of their students. Teachers could also include practice analysis as a large-group activity, where students present short videos of their own practice during class time and discuss the effectiveness of their practice behavior with their peers and their teacher. Giving students regular feedback about their own practice may ensure that students set appropriate goals for their practice and know when and how to adjust their practice behavior to achieve their goals. Including practicing as an instructional topic that is taught, sequenced and assessed can improve the quality of student practice and, ultimately, the quality of their performance.

Conclusions and Questions for Further Research

Our study indicates that individuals who exhibit more successful music performance outcomes practice differently than individuals who are less successful, which corroborates many existing observations about practice behavior across a variety of experience levels (Duke, Simmons, and Cash 2009, 315–317; Miksza, Prichard, and Sorbo 2012, 259–261; Palese and Duke 2021, 5–7; Pike 2017, 744–748). These results prompt a few questions to be addressed in future research. What goals do novice musicians set for themselves during practice? In our study, most participants seemed to prioritize musical accuracy (playing the right notes at the right time), with little or no attention paid to technique, fluency or musical inflection. Although some participants were able to play accurately, their playing lacked the fluidity and musical expression that characterize excellent music performance.

Investigations of novice musicians' thoughts about their independent practice may reveal misperceptions about the mechanisms involved in refining skills. Given that few novice musicians have observed examples of effective practice, it may be that their conceptions about how musicians learn and improve are not consistent with what actually takes place when musicians practice effectively. Further observations about how musicians make lasting changes in their own playing, particularly when correcting mistakes, may facilitate more successful learning experiences for aspiring musicians. ◂◂

Notes

1. The characteristic "at least 20% of all starts were complete, correct performances, although not necessarily at the target tempo of 120 bpm" (p. 317) was not included in our study because of study design differences. Duke and colleagues' study design included an additional test condition where participants were asked to perform 15 successive trials of the test excerpt 24 hours after the initial practice period." Since our study did not include this test condition, we eliminated that characteristic from our analysis.

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