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Author(s): Peter Miksza

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An Investigation of Observed Practice Behaviors, Self-Reported Practice Habits, and the Performance Achievement of High School Wind Players

Peter Miksza
University of Colorado, Boulder

The primary goal of this study was to examine relationships among observed practice behaviors, self-reported practice habits, and performance achievement of high school wind players (N = 60). Participants practiced in three 25-minute sessions, rated their practice efficiency following each day, and completed a practice survey. Participants performed a researcher-composed étude six times across the duration of the study. Performances were rated using objective and subjective criteria. Practice sessions were observed for frequencies of selected practice behaviors. Interjudge reliability for performance ratings and observations was acceptable to high. A significant change ($p < .001$) in performance achievement was detected over time ($d = .85$). The behaviors exhibited the most were *repeat measure, repeat section,* and *marks part.* Significant correlations were found: (a) among the behaviors *repeat section, whole-part-whole,* and *slowing;* (b) between performance achievement and the behaviors *repeat section, whole-part-whole, slowing,* and *skipping directly to or just before critical musical sections of the étude;* and (c) between performance achievement and self-reports of percentage of time spent on formal and informal practice and use of metronome. Self-evaluations of practice efficiency were strongly related to performance achievement scores at day one, less so at day two, and not at all on day three. Lastly, several small relationships were also found between self-reported practice habits and observed practice behaviors.

Keywords: *instrumental music; practicing; performance achievement; practice behaviors; practice habits; deliberate practice*

Music practice is a crucial element of every musician's development. Many studies have documented the large quantities of time musicians devote to practicing, whether they be beginner or intermediate learners (e.g., Sloboda, Davidson, Howe, & Moore, 1996), advanced students (e.g., Smith, 2002), or professionals (e.g., Lehmann & Ericsson, 1997). Researchers and practitioners alike recognize the need for determining which practice approaches and specific practice behaviors are the most effective for increasing performance achievement. As a result, several lines of

This article is based on the author's doctoral dissertation, "Relationships Among Impulsivity, Achievement Motivation, Practice Behavior, and the Performance Achievement of High School Wind Player," completed at Indiana University in 2007. Address correspondence to Peter Miksza, College of Music, 301 UCB Boulder, CO 80309-0301, (303) 492-1782; peter.miksza@colorado.edu

research have emerged that have linked general approaches to practicing with achievement. For example, studies have shown that modeling (e.g., Fortney, 1992; Hewitt, 2001; Rosenthal, 1984), the combination of mental practice with physical practice (e.g., Miksza, 2005; Ross, 1985), structured practice routines (e.g., Barry, 1990), and self-regulated behavior (e.g., Austin & Haefner Berg, 2006; McPherson & Zimmerman, 2002) may be important elements of effective practice. However, little is still known regarding which specific practice behaviors are the best predictors of performance achievement.

Lehmann and Ericsson (1997) have proposed the concept of deliberate practice as a framework for studying the acquisition of musical expertise. Deliberate practice encompasses effortful, goal-directed, and intentionally structured activities. Although it exists in the larger context of music practice in general, the concept of deliberate practice requires sustained concentration and effort and is therefore somewhat distinct from unstructured activities engaged in for the sake of playing for fun. The researchers suggest that it is primarily through deliberate practice that musicians are able to develop the skills and perceptual abilities that lead to achievement. Lehmann and Ericsson cite three main sources of evidence for their theoretical model of the acquisition of musical expertise: (a) self-reports of amount and type of practice activity throughout a musician's career (e.g., Ericsson, Krampe, & Tesch-Romer, 1993); (b) physical adaptations found in musicians as compared to nonmusicians, such as ranges of limb movement and brain activation patterns (e.g., Elbert, Pantev, Weinbruch, Rockstroh, & Taub,1996); and (c) historical accounts of increases in musical performance, such as increases in the achievement of child prodigies and increases in the complexity of Western art music over time. However, it is clear that more empirical evidence regarding the amount and type of practice that developing musicians undertake is necessary.

Studies that incorporate behavioral analyses of music practicing have become increasingly common (e.g., Geringer & Kostka, 1984; Ginsborg, 2002; Hallam, 2001; Maynard, 2006; McPherson & Renwick, 2001; Nielsen, 1999; Smith, 2002). Of the studies that have incorporated behavioral analyses, only a few have also included dependent measures of performance achievement (Killian & Henry, 2005; Miksza, 2006) or musical competence (Gruson, 1988). Gruson (1988) investigated the practice behaviors of 43 pianists varying in competency from beginners to professionals. The participants practiced three études of contrasting style (which varied by competence level) for any length of time they desired. The researcher found that the behavior *repeat section* (i.e., repeating material greater than a measure in length) was the best positive predictor of competence level. A subsample of 16 participants was also asked to practice for an additional nine sessions under the same conditions. Results indicated that the less competent participants spent all of the sessions gradually increasing speed and accuracy whereas the more competent participants reached performance tempo more quickly and worked on finer aspects of musicality. However, comparisons made between participants must be interpreted carefully, given that the varied amount of time participants spent practicing and lack of controlled musical materials could have confounded results. Research that incorporates multiple practice

sessions, consistent musical materials across participants, and a controlled amount of time is necessary to confirm these results.

Miksza (2006) examined relationships among observed practice behavior and pre- and posttest measures of performance achievement with a sample of 40 college brass players. Participants practiced a researcher-adapted étude for 23 min with a goal of making the most improvement they could by any means possible. Significant positive relationships were found between performance achievement scores and the practice behaviors *repeat section*, *whole-part-whole*, *marks part*, and *varying pitch*. When taken together, the findings suggest that those who took a more strategic approach toward practicing (e.g., breaking parts down and putting them back into context, identifying difficult spots) also achieved the highest performance scores. Similarly, Killian and Henry (2005) found that high school vocalists who used the strategy *isolated problem areas* in the 30 sec prior to performing a singing task outperformed those who did not. More studies are needed to determine whether these results could be generalized to high school instrumentalists.

Researchers have also investigated music practice behavior by means of self-report (e.g., Byo & Cassidy, 2004; Hamann, Lucas, McAllister, & Teachout, 1998; Smith, 2002). However, only a small number of studies have examined the relationships between self-reported practice behaviors and performance achievement (Jorgensen, 2002) or musical competence (Barry, 1991; Sloboda et al., 1996). Jorgensen (2002) found that conservatory musicians who had received *excellent* performance exam evaluations reported significantly greater amounts of practice time than those who received *very good* or *good* ratings. However, no attempts were made to differentiate what type of practice activities were being used by the participants. In contrast, Barry (1991) found that high school and community college musicians reported using the strategies (a) practicing small sections before playing through the entire piece, (b) using a metronome, and (c) listening to recordings of the material being practiced significantly less than professional musicians. In addition, Sloboda et al. (1996) found that British instrumentalists ages 8 to 18 who were admitted to a specialist music school reported significantly more time practicing repertoire and technical work than those who had not been admitted or ceased playing their instruments. The same participants also reported significantly more technical work in the morning, reported more time in individual lessons, and were more consistent in their practice patterns from week to week. Although these self-report findings are informative in their own right, it is important to confirm them with observational evidence.

Although several lines of research (e.g., deliberate practice, mental practice, modeling, self-regulation) have begun to show links between general practicing approaches and achievement, relatively little is known about which specific behaviors are most effective in eliciting performance gains. Information regarding which behaviors are beneficial to school-age musicians is especially needed, given their often limited formal training and the scarcity of studies with this population. The purpose of this study was to examine relationships among observed practice behaviors, self-reported practice habits, and the performance achievement of high school wind players.

Method

Volunteer participants (N = 60) from six high school band programs in Indiana and New Jersey were recruited for this study. The schools varied greatly in demographic characteristics, size, district expenditure per student, number of band directors, and number of curricular bands. Only wind players with at least 2 years or more of playing experience on their current instrument were recruited. The sample consisted of 30 males and 30 females from Grades 9 through 12 with a mean age of 16.23 years (SD = 1.13). The specific instruments played included flute, oboe, bassoon, clarinet, bass clarinet, alto saxophone, tenor saxophone, horn, trumpet, trombone, and euphonium. Of the participants, 47 reported they were taking private lessons.

Participants in this study participated in three practice sessions, one session on each of three separate and consecutive days. All participants practiced individually during their usual band class or study hall time in a private room separate from the rehearsal hall. Each session lasted approximately 35 min, with a total of 105 min of time across the three sessions. The sessions were broken into seven parts lasting the following approximate lengths of time: (a) 1 min acclimation to practice room (e.g., warm-up), (b) 3 min pretest performance, (c) 1 min transition, (d) 25 min practice, (e) 1 min transition, (f) 3 min posttest performance, and (g) 1 min self-evaluation of practice efficiency. Therefore, participants had a total of 75 min to devote to actual music practicing in this study. The 25 min of practicing during each session was monitored with a digital timer. Evidence from previous research (e.g., Fortney, 1992; Miksza, 2005) regarding the amount of time necessary to observe significant gains in performance achievement as well as pilot study results were considered when choosing this practice length. The three sessions yielded six measures of performance achievement—a pretest and posttest score for each session.

The researcher escorted each participant to his or her room and initiated the recorder but was not present during the performances or practice sessions. This decision was made in light of previous evidence regarding social facilitation theory, which states that even in the absence of overt social cues (e.g., competition, evaluation, reinforcement), the mere presence of an observer can influence an individual's behaviors and/or emotions by increasing arousal (e.g., Martens, 1969; Zajonc, 1965). All participants received an unmarked copy of the étude and a pencil and were provided with these instructions:

> Practice the étude for the next 25 minutes in any way that you want—you may write on this étude if you want—the étude is designed to allow for both musical/expressive and technical improvement to be made across the entire study—try to make as much improvement as you can.

Pre- and posttest performances as well as practice sessions were digitally recorded with a Sony MZ-R700 minidisc recorder and Sony ECM-MS907 microphone (signal-to-noise ratio 62 dB). Following each session, participants rated their practice

efficiency using a one-item, 10-point Likert-type scale (i.e., 1 = *extremely inefficient* to 10 = *extremely efficient*). A researcher-composed performance étude (see appendix) was designed for this study with considerations for the following criteria: (a) length (2 to 3 min), (b) instrument range (two octaves), (c) style (legato and detached), (d) tempo (moderato and allegro), (e) key (F concert), (f) meter (common time), (g) rhythmic values (duple and triple), (h) accidentals (modulatory and minor borrowings), (i) articulation markings (slurred and detached), (j) dynamic contrasts (*pp* to *ff*), and (k) level of difficulty. These criteria were chosen to present performance challenges related to contrasting styles, contrasting tempi, duple versus triple rhythmic subdivision, expressive techniques, tongue coordination, finger coordination, and diatonic versus chromatic note reading. A pilot test with high school students indicated that the étude was accessible yet challenging for players varying widely in skill level. All participants played the same étude with only minimal accommodation for notes beyond an instrument's playable range (i.e., transposed by octave). The étude was collected at the conclusion of each session.

Objective and subjective measures of performance achievement were included in this study. The objective performance measure (OPM) was an adaptation of the Watkins-Farnum Performance Scale (WFPS; Watkins & Farnum, 1954). For the purposes of this study, the number of errors in notes, rhythms, articulations, and dynamics were measured by counting the number of beats performed incorrectly on either dimension. The WFPS scoring system was therefore modified to include each beat rather than each measure. Given that the étude contained 200 beats, the highest total score on the OPM was 200 points. The subjective performance measure (SPM) was an adaptation of Zdzinski's (1993) Performance Rating Scale Supplement (PRSS). The PRSS was originally designed by Zdzinski to measure subjective elements not included in the WFPS. The adaptation of the PRSS used in this study consisted of 39 five-point Likert-type items and allowed for a possible range of 39 to 195 points. The items addressed the following categories: (a) étude-specific criteria (e.g., the decrescendo in Measure 8 reaches a true *piano*), (b) interpretation–musical effect (e.g., performer plays mechanically), (c) tone–intonation (e.g., the quality of the tone was rich), and (d) technique–articulation (e.g., attacks and releases were clean). Internal consistency of the SPM for the current study was found to be excellent across all time points (α = .96 to .98).

Because of the intensive judging duties required for this study, the researcher participated as a judge and scored 100% of the performances. Two additional judges, graduate wind players and experienced music educators from a large midwestern university, scored 50% of the participants' performances to provide a reliability assessment. The judges used separate CDs containing uniquely randomized presentations of the performances and were blind to participant identity as well as time point of performance (Pretest 1, Posttest 1, Pretest 2, etc.). Interjudge reliability results for the OPM and SPM scores in the current study ranged from α = .86 to .97 across each time point. In addition, strong Pearson correlations were detected between OPM and SPM scores at each time point (r = .72 to .83). Therefore, a composite

performance achievement score (Comp) was created for each time point using equally weighted OPM and SPM *T* scores.

Audio recordings of participants' practice sessions were analyzed for frequencies of the following behaviors: *repeat measure*, *repeat section*, *whole-part-whole*, *chaining*, *repeat étude*, *slowing*, *varying pitch*, *varying articulation*, *varying rhythm*, *non-étude-related playing*, *singing or whistling*, *use of metronome*, and *marks part*. The behavior *repeat section* was operationally defined as any time a participant repeated a segment of the étude larger than a measure. *Whole-part-whole* practicing entailed instances when a participant played a segment of music, isolated a smaller phrase or unit of any kind within the larger segment, and then played the entire segment again. *Chaining* behaviors consisted of playing a segment of music and systematically adding segments that appeared either before or after the original segment. The number of times a participant began playing directly on or just before five researcher-selected critical musical sections was counted, as well (i.e., *skipping directly to or just before Sections 1 through 5*). The critical musical sections selected were those that appeared to present the most difficulty to participants in the pilot study. Section 1 contains a passage of 8th- and 16th-note figures (Measures 14–16), Section 2 contains a large octave leap and complex scalar passages (Measure 26–29), Section 3 contains an abrupt change to triplet figures (Measures 32–33), Section 4 contains a 16th-note passage in the upper range (Measure 43), and Section 5 contains a large octave leap, scalar motion, and complex articulation patterns (Measures 46–49). Durational recording of time spent playing was measured with a stopwatch. The behavior *marks part* was assessed by frequency counts of marks made on the practice étude. Practice behaviors were identified through continuous observational recording during the participants' practice sessions. Several of the behaviors were operationally defined by the researcher on the basis of informal observation, pilot study results, and teaching experience, and others were drawn from scales by Gruson (1988) and Smith (2002) for pianists and strings, respectively.

A sample of 25% of the individual practice session recordings was randomly selected by the researcher for analysis by an independent observer, a graduate wind player from a large midwestern university with 5 years of public school teaching experience. Frequency count reliability was calculated with the equation (number of agreements)/(number of agreements + disagreements) for each behavior at each day. The results indicated acceptable reliability with percentage agreement ranging from 68% to 100% for each behavior across all days, with the exception of the behaviors *varying pitch* and *varying rhythm*. However, the lack of agreement between judges on these behaviors was likely because of their relative rarity and the subsequent lack of variability in the frequency distributions found. Therefore, the behaviors *varying pitch*, *varying articulation*, and *varying rhythm* were combined into one, labeled *varying musical elements*, for the main analyses. The reliability of the measurement of duration of time spent playing for each day was assessed with Spearman correlations and resulted in coefficients ranging from $r = .83$ to .91.

Participants' self-reports of practice habits were collected with a researcher-constructed survey. The items addressed the following habits: (a) length of average practice session in minutes, (b) average number of practice sessions each week, (c) average percentage of time spent on formal and informal practice (e.g., with or without a specific technical or musical goal), (d) frequency of listening to recordings while practicing, (e) frequency of recording themselves practicing, (f) frequency of using a metronome while practicing, (g) frequency of using an electronic tuner while practicing, and (h) general belief regarding personal practice efficiency (see Table 1).

Results

Self-Reported Practice Habits

Descriptive analyses of the practice habit items revealed that the mean length of average practice session reported was 33.42 min and was quite varied across the sample ($SD = 15.95$; see Table 1). The skewness and kurtosis figures indicated that the reports of average practice session time were not normally distributed and tended to group below the mean. The majority of the sample (78.3%) reported practicing for one session per day. Small percentages of the sample also reported practicing for zero (5.0%), two (8.3%), and three (3.3%) sessions per day. Mean reports for average percentage of time spent on informal and formal practice were 36.88% ($SD = 24.95$) and 61.77% ($SD = 24.96$), respectively. The participants' mean responses to the items regarding how often they listen to recordings, record themselves, use a metronome, and/or use a tuner while practicing indicated that these were strategies that were generally used rarely. For example, the mean response for the item "How often do you record yourself while practicing?" was 1.63, which indicates that the sample never or almost never used that strategy. The mean for average daily practice efficiency was 6.82 ($SD = 1.43$), indicating that participants considered themselves only moderately efficient.

Descriptive analyses of the self-evaluations of practice efficiency following each practice session in the study indicated that the participants rated their practicing as somewhat efficient for each of the 3 days ($M = 6.15$ to 6.92; see Table 1). A repeated-measures analysis of variance was conducted to determine whether the mean ratings increased significantly from Day 1 to Day 3. The results indicated that the means were significantly different across time ($p < .01$). Within-participants' contrasts showed significant ($p < .05$) increases in practice efficiency between each time point. The largest effect was found between the means for Day 1 and Day 2 ($eta^2 = .16$). However, this finding suggests only minimal practical significance.

Spearman correlations among the practice habit items indicated significant ($p < .01$) relationships between (a) average number of sessions per day and average daily practice efficiency ($rho = .46$), (b) average number of sessions per day and use of tuner ($rho = .38$), and (c) formal and informal practicing ($rho = -.90$). With the exception of the inverse relationship between formal and informal practicing, the positive coefficients

Table 1
Descriptive Statistics for Self-Reported Practice Habits, Self-Evaluations of Practice Efficiency Following Each Session, and Composite Performance Achievement Scores

Item	*M*	*SD*	Skew	Kurtosis
Length of average practice session	33.42	15.95	1.72	4.35
Average number of practice sessions per day	1.13	0.55	1.54	4.30
% of time spent on informal practice	36.88	24.95	0.86	–0.19
% of time spent on formal practice	61.77	24.96	–0.72	–0.37
How often do you listen to recordings?[a]	2.32	0.81	–0.26	–0.79
How often do you record yourself?[a]	1.63	0.76	0.74	–0.87
How often do you use a metronome?[a]	2.78	1.09	–0.20	–0.71
How often do you use a tuner?[a]	3.03	1.29	–0.16	–1.01
Average daily practice efficiency[b]	6.82	1.43	–0.71	0.91
Self-evaluation of efficiency Day 1[b]	6.15	1.52	–0.32	–0.64
Self-evaluation of efficiency Day 2[b]	6.75	1.57	–0.52	–0.59
Self-evaluation of efficiency Day 3[b]	6.92	1.77	–0.52	–0.12
Composite performance achievement 1–1[c]	50.00	9.43	–0.25	0.40
Composite performance achievement 1–2	54.99	10.58	–0.04	–0.22
Composite performance achievement 2–1	55.06	10.13	0.16	–0.11
Composite performance achievement 2–2	56.77	10.61	–0.07	0.07
Composite performance achievement 3–1	57.29	10.12	–0.01	–0.46
Composite performance achievement 3–2	58.04	11.27	–0.54	0.97

a. Scale is 1 = *never*, 2 = *almost never*, 3 = *occasionally*, 4 = *almost always*, 5 = *always*.
b. Scale is 1 = *extremely inefficient* to 10 = *extremely efficient*.
c. 1–1 = Day 1 pretest, 1–2 = Day 1 posttest, 2–1 = Day 2 pretest, etc.

suggest that those who reported greater amounts of one habit also tended to report greater amounts of the other. Significant positive coefficients ($rho = .26$, $p < .05$, to $rho = .57$, $p < .001$) were also found between item pairs pertaining to the specific practice strategies listening to recordings, recording oneself, use of metronome, and use of tuner, with the exception of the items "How often do you listen to recordings?" and "How often do you use a tuner?" ($rho = .24$, $p > .05$). These findings indicate that individual participants were likely to use these strategies with relatively similar frequency.

Performance Achievement

The mean composite performance achievement scores increased from Day 1 ($M = 50.00$) through 3 ($M = 58.04$; see Table 1). Standard deviations showed that the scores were least varied at Day 1 pretest ($SD = 9.43$) and most varied at Day 3 posttest ($SD = 11.27$). A mixed-design analysis of variance indicated that performance achievement means did not differ significantly ($p > .05$) by sex, whether participants played brass or woodwind instruments, or whether participants had taken private lessons. However, a significant ($p < .001$) difference was found among mean performance

achievement scores over time. The effect size calculated for the change from Day 1 pretest to Day 3 posttest was quite large ($d = .85$). However, it is important to note that the majority of this change occurred between Day 1 pretest and Day 1 posttest. Polynomial contrasts indicated significant ($p < .05$) linear, quadratic, cubic, and quartic effects. However, given the relative eta^2 values for each of these effects as well as a visual inspection of a mean plot, it is clear that the linear and quadratic effects represent the most meaningful results.

Relations Between Performance Achievement and Self-Reported Practice Habits

Small yet significant ($p < .05$) negative correlations were detected between reports of percentage of time spent on informal practice and all composite performance achievement scores (*rho* = –.26 to –.34; see Table 2). Inversely, significant ($p < .05$) positive correlations were found between reports of percentage of time spent on formal practice and performance achievement at Day 1 pretest, Day 2 pretest, Day 3 pretest, and Day 3 posttest (*rho* = .27 to .29). These results indicate that those who reported greater percentages of informal practicing tended to have lower performance achievement scores, whereas those who reported greater percentages of formal practice tended to have higher scores. In addition, reports of how often participants used a metronome while practicing were significantly ($p < .05$) related to all performance achievement scores across time (*rho* = .29 to .36), suggesting a similar trend between those who reported using a metronome and higher performance scores. However, the coefficients for these findings indicate relatively small effects. Although several other significant correlations were detected among performance achievement and self-reported practice habits, these relationships were inconsistent across time and relatively weak (see Table 2).

Observed Practice Behaviors

All practice behaviors were exhibited on each day with the exception of the behavior *use of metronome*, which was observed only on Day 1 (see Table 3). The behavior *repeat measure* was exhibited by 100% of the sample and had the highest mean frequency across all days ($M = 63.90$ to 89.82). The behavior *repeat section* was the second most common behavior used ($M = 16.65$ to 20.63) and was also consistently exhibited by a large proportion of the sample across each day (95.0% to 96.7%). The behavior *marks part* also had a high mean (41.15) and was exhibited by 85% of the sample. The next most frequent behaviors exhibited were *slowing* and *non-étude-related playing*, with means ranging from 2.40 to 3.52 and 1.77 to 2.12, respectively. *Slowing* was exhibited by 75% to 80% of the sample across the 3 days, whereas *non-étude-related playing* was exhibited by only 40% to 56.7% of the sample. No other behaviors had mean frequencies above 2 on any day. Although the mean frequency counts were relatively small, the behavior *whole-part-whole* was exhibited

Table 2
Spearman Correlations Between Composite Performance Achievement Scores and Self-Reported Practice Habits

Item	Comp 1–1[a]	Comp 1–2	Comp 2–1	Comp 2–2	Comp 3–1	Comp 3–2
Length of average practice session	.18	.24	.14	.28*	.22	.22
Average number of sessions per day	.02	.04	.12	.08	.15	.15
% of time spent on informal practice	–.34*	–.26*	–.32*	–.28*	–.33*	–.34*
% of time spent on formal practice	.27*	.20	.28*	.23	.29*	.27*
How often do you listen to recordings?	.19	.09	.10	.12	.18	.05
How often do you record yourself?	.12	.10	.10	.09	.13	.10
How often do you use a metronome?	.36**	.36**	.29*	.33*	.34**	.34*
How often do you use a tuner?	.21	.21	.18	.11	.12	.16
Average daily practice efficiency	.22	.22	.29*	.19	.23	.25

Note: Comp = composite performance achievement.
a. 1–1 = Day 1 pretest, 1–2 = Day 1 posttest, 2–1 = Day 2 pretest, etc.
*$p < .05$. **$p < .01$.

by a majority of the participants on each day (51.7% to 63.3%). In addition, a majority of the participants (51.7% to 58.3%) did frequently skip directly to or just before critical musical Sections 1, 2, and 5 on each day. The behaviors used the least were *use of metronome* and *repeat étude*. Only 2 participants used a metronome during the study. All other behaviors had means lower than 1 and were exhibited by less than 50% of the sample on any given day.

The mean duration of time spent playing across the 3 days ranged from 16.67 min (Day 3) to 18.45 min (Day 1). The duration of time spent playing was quite varied within each day (SD = 2.62 to 3.64), ranging from 12.22 to 23.95 min, 12.48 to 22.83 min, and 8.38 to 22.98 min for Days 1, 2, and 3, respectively. A repeated-measures analysis of variance revealed that the mean duration of time spent playing on Day 3 was significantly ($p < .001$) less than that for Days 1 and 2. Friedman analyses of variance indicated significant differences ($p < .001$) for the behaviors *repeat measure* and *repeat section* over time. Overall, significantly fewer *repeat measure* and *repeat section* behaviors were observed on Day 3 than on Days 1 and 2. No other significant differences were found across days.

Preliminary analyses indicated moderate to strong correlations among the practice behaviors exhibited by more than 50% of the sample, suggesting that those who were more likely to use a particular behavior on Day 1 were also more likely to exhibit that same behavior on Days 2 and 3. Therefore, composite variables were created for each behavior to enable a more parsimonious analysis. Correlations were calculated between all possible pairs of composite behaviors that were exhibited by

Table 3
Descriptive Statistics for Practice Behaviors Observed

	Day 1			Day 2			Day 3		
Practice Behavior	*M*	*SD*	% > 0[a]	*M*	*SD*	% > 0[a]	*M*	*SD*	% > 0[a]
Repeat measure*	89.82	42.30	100.0	84.28	45.07	100.0	63.90	42.09	100.0
Repeat section*	19.35	12.45	96.7	20.63	12.81	96.7	16.65	12.17	95.0
Whole-part-whole	1.30	1.80	51.7	1.80	2.10	63.3	1.15	1.48	53.3
Chaining	0.27	0.61	20.0	0.38	0.85	25.0	0.23	0.50	20.0
Repeat étude	0.15	0.92	5.0	0.12	0.90	1.7	0.25	1.31	10.0
Slowing	3.52	3.35	80.0	3.05	2.68	86.7	2.40	2.61	75.0
Varying pitch	0.62	1.65	23.3	0.35	0.73	23.3	0.75	1.55	31.7
Varying articulation	0.12	0.67	5.0	0.20	0.66	11.7	0.35	1.88	8.3
Varying rhythm	0.30	0.74	18.3	0.33	0.71	21.7	0.60	1.06	41.7
Varying musical element[b]	1.03	2.13	33.3	0.88	1.33	41.7	1.70	2.69	53.3
Non-étude-related playing	1.87	3.92	40.0	1.77	2.78	50.0	2.12	3.04	56.7
Sing/Whistle/Buzz	1.07	1.93	36.7	0.97	1.85	31.7	0.55	1.21	26.7
Use of metronome	0.30	1.63	3.3	0.00	0.00	0.0	0.00	0.00	0.0
Section 1	0.88	1.14	56.7	1.03	1.25	55.0	0.95	0.96	65.0
Section 2	1.17	1.57	58.3	1.20	1.45	65.0	1.40	1.87	63.3
Section 3	0.55	1.31	31.7	0.50	0.72	36.7	0.65	0.92	43.3
Section 4	0.60	1.43	30.0	1.00	1.48	50.0	0.95	1.31	53.3
Section 5	0.93	1.31	51.7	1.20	1.34	63.3	1.33	1.16	71.7
Marks part[c]	41.15	46.67	85.0	NA	NA	NA	NA	NA	NA
Duration playing*[d]	18.45	2.79	NA	17.93	2.62	NA	16.67	3.65	NA

a. Percentage of cases who exhibited this behavior at least once.
b. Varying musical element is a composite of varying pitch, varying articulation, and varying rhythm.
c. Frequency of this behavior only counted across all 3 days.
d. Minutes spent playing.
* = significantly different over time ($p < .001$).

more than 50% of the sample at each day. Moderately strong relationships were detected among the behaviors *repeat section*, *whole-part-whole*, and *slowing* (*rho* = .39 to .66, $p < .01$), indicating that those who were more likely to exhibit the behavior *repeat section* were also more likely to use *whole-part-whole* and *slowing* behaviors and vice versa. Relatively strong correlations were also found between the behaviors *skipping directly to or just before critical Sections 1, 2, and 5* (*rho* = .51 to .59, $p < .01$), indicating that participants who were likely to skip directly to or just before critical musical Section 1 while practicing also tended to skip directly to or just before Sections 2 and 5 and vice versa. A moderately strong significant relationship ($p < .001$) was also detected between the behaviors *repeat measure* and duration of time spent playing (*rho* = .46). Those who exhibited more *repeat measure* behaviors also tended to spend greater amounts of time playing during the study. Most of the

correlations determined between the composite behaviors exhibited by more than 50% of the sample and self-reported practice habits were nonsignificant. Those that were significant were relatively small and may have limited practical significance (e.g., *rho* $< .35$).

Relations Among Observed Practice Behaviors and Performance Achievement

Correlations between the practice behaviors exhibited by more than 50% of the sample and composite performance achievement scores were also examined for each day of the study (Table 4). The behavior *repeat section* was significantly related ($p < .01$) to pre- and posttest composite performance achievement scores at Day 1 and Day 2 (*rho* $= .36$ to .42). The behavior *slowing* was significantly related ($p < .05$) to pretest composite performance achievement scores at Days 1 (*rho* $= .36$) and 2 (*rho* $= .43$) as well as to posttest composite performance achievement scores at Day 3 (*rho* $= .30$). In addition, the behavior *whole-part-whole* was significantly correlated ($p < .01$) with pre- and posttest composite performance achievement scores at Days 2 and 3 (*rho* $= .35$ to .45). Small yet significant correlations ($p < .05$) were detected between performance achievement and the behaviors regarding skipping to critical musical sections of the étude. The behavior *skipping directly to or just before Section 1* was significantly related to posttest performance achievement scores at Day 2 (*rho* $= .28$), whereas the behavior *skipping directly to or just before Section 2* was related to posttest performance achievement scores at Day 3 (*rho* $= .27$). Significant relationships ($p < .05$) were also found between the behavior *skipping directly to or just before Section 5* and Day 1 pretest (*rho* $= .34$) and posttest (*rho* $= .37$) performance achievement scores. These relationships indicate that those with higher performance achievement scores also exhibited more of each respective behavior.

Relations Among Performance Achievement and Self-Reports of Practice Habits

Moderately strong significant correlations (*rho* $= .57$ to .61, $p < .001$) were detected between practice efficiency ratings for Day 1 and all composite performance achievement scores at each time point. In contrast, the correlations found between efficiency ratings at Day 2 and composite performance achievement scores at each time point were consistently less pronounced (*rho* $= .35$ to .37, $p < .01$). In addition, no significant correlations ($p > .05$) were detected between efficiency ratings at Day 3 and performance achievement scores at any time point. Overall, these findings demonstrate a trend that suggests that the participants' efficiency ratings were more closely related to their performance achievement at Day 1 than any other day. It is important to note that the declining degree of association over time is apparently not because of a lack of variance in the two variables.

Table 4
Spearman Correlations Between Composite Performance Achievement Scores, Behaviors Exhibited by at Least 50% of the Participants at Each Day, and Self-Evaluations of Daily Practice Efficiency

	Comp 1–1	Comp 1–2	Comp 2–1	Comp 2–2	Comp 3–1	Comp 3–2
Practice Behavior	With Day 1 Behaviors		With Day 2 Behaviors		With Day 3 Behaviors	
Repeat measure	–.08	–.15	.01	.06	–.22	–.19
Repeat section	.36**	.40**	.42**	.40**	.19	.20
Whole-part-whole	.19	.22	.35**	.40**	.45**	.39**
Slowing	.36**	.43***	.30*	.24	.09	.11
Section 1	.11	.05	.29	.28*	.08	.10
Section 2	–.02	–.01	.25	.19	.24	.27*
Section 5	.34**	.37**	.17	.13	.02	.03
Marks part[a]	.03	.08	.17	.23	.17	.23
Duration played	.01	–.07	.17	.23	–.04	–.03
Self-evaluation Day 1	.59***	.61***	.58***	.63***	.57***	.61***
Self-evaluation Day 2	.36**	.37**	.36**	.36**	.36**	.35**
Self-evaluation Day 3	.03	.04	.03	.07	.03	.08

Note: Comp = composite performance achievement; 1–1 = Day 1 pretest, 1–2 = Day 1 posttest, 2–1 = Day 2 pretest, etc.
a. Frequency of this behavior only counted across all 3 days.
*$p < .05$. **$p < .01$. ***$p < .001$.

Discussion

The relationships found among observed practice behaviors, self-reported practice habits, and performance achievement scores have important implications for theoretical conceptions of deliberate practice (e.g., Lehmann & Ericsson, 1997). For example, the correlations among the observed behaviors *repeat section*, *whole-part-whole*, and *slowing* suggest that some individuals are more likely to approach practicing more strategically than others. Furthermore, these same behaviors were significantly related to measures of performance achievement. These findings support those of Miksza (2006) and Gruson (1988), who found similar relationships among strategic behaviors such as these and performance achievement and musical competence. Behaviors such as these may be particularly useful for identifying elements of deliberate practice. However, it is also important for researchers to consider more detailed approaches to studying repetition behaviors. For example, refining the operational definitions of *repeat measure* and *repeat section* behaviors to be more specific than repetitions of material less than one measure or greater than one measure, respectively, would aid researchers in examining how individuals analyze and choose materials to address while practicing.

The results also have practical implications for music educators. Although the findings cannot be considered causal, the correlations between performance achievement and the behaviors *repeat section*, *slowing*, *whole-part-whole*, and *skipping*

directly to or just before critical musical sections of the étude indicate that these may be particularly useful strategies for making improvement. Teachers could design lesson or rehearsal plans that specifically guide students to apply these strategies when learning new music. Teachers could devise methods for demonstrating how to identify and focus on difficult or problematic musical passages when practicing. In contrast, the lack of significant relationships found between durations of time spent playing and performance achievement scores indicates that teachers should stress that the amount of time spent playing is not necessarily an indicator of how much improvement is being made while practicing. A lack of correlation between time spent playing and performance achievement was also found by Miksza (2006). In general, the results of this study have shown that the quality of practicing that takes place may be more crucial to improvement than the quantity of time spent playing.

The correlations found between self-reported practice habits and performance achievement also suggest that the quality of one's practicing may be more important than the quantity of time spent playing. Participants reporting higher percentages of formal practice tended to have higher performance achievement scores. It may be that those who were more accustomed to practicing with specific musical or technical goals in mind were able to practice more effectively during the study. These results are similar to those of Sloboda et al. (1996), who found that higher achieving students spent more time on technical work and were more organized in their practice. This suggests that teachers should guide students toward practicing with musical and/or technical goals in mind. This could be done by assigning specific musical passages to students or by asking students to practice applying specific musical concepts (dynamic contrasts, vibrato, expressive tempo manipulation, etc.) to various pieces when working alone.

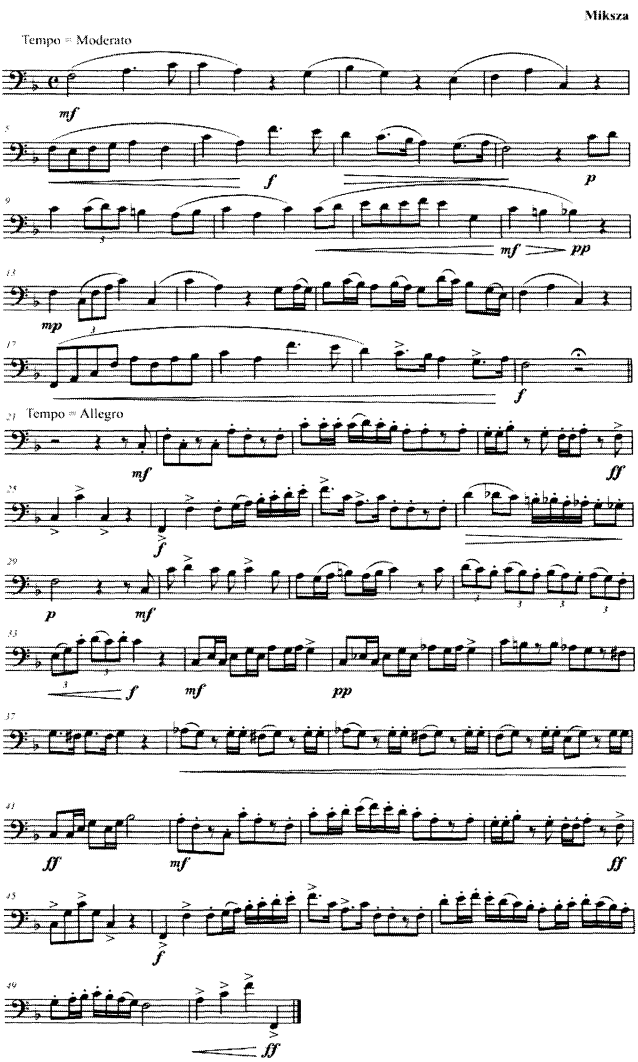
The results also indicated that the discrepancy between participants' self-evaluations of practice efficiency and performance achievement grew larger over time. Similar results were reported by McPherson and Renwick (2001), who found that beginning instrumentalists often play through material from top to bottom without recognizing or stopping for errors. This suggests students may need to be trained to distinguish between efficient and inefficient practicing. For example, teachers could demonstrate characteristics of inefficient practicing, such as repetition of errors and physical and/or mental fatigue, and warn students to guard against them. Conversely, teachers could also highlight characteristics of efficient practice, such as focusing on problematic passages and taking appropriate amounts of rest.

Music practice is undoubtedly an important topic to investigate, given the immense amounts of time and energy all musicians must devote to practicing throughout their lives. This study examined the music practice of high school wind players from multiple perspectives. Particular strengths of the study were (a) a sample with diverse demographic characteristics, (b) a sample that varies in performance medium (e.g., brass and woodwind), (c) multiple methods of data collection (e.g., observation as well as self-report), (d) the inclusion of dependent measures of performance achievement, and (e) data collection across multiple practice sessions (e.g., 3 days). The results from

this study represent valuable contributions to the body of existing information regarding the nature of music learning and avenues for further study of deliberate practice. Ultimately, the findings of this study, with replication and extension, may serve to aid performers and teachers address important issues regarding music practice.

Appendix

Practice Étude



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Peter Miksza is assistant professor of music education at the University of Colorado at Boulder. His primary research interests include investigating music practicing and issues related to music teacher education.

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