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When Repetition Isn't the Best Practice Strategy: Effects of Blocked and Random Practice Schedules

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Abstract

The purpose of this study was to investigate the effects of blocked and random practice schedules on the performance accuracy, speed, temporal evenness, and attitude of beginning band students in a group instructional setting. The research assumptions were based on the contextual interference hypothesis, which predicts that a blocked practice order (low contextual interference) leads to superior performance immediately following practice but that a random practice order (high contextual interference) supports superior performance at delayed retention testing. Beginning clarinet students ($N = 41$) completed three practice sessions and one retention testing session, performing three seven-pitch exercises. At the end of practice, no significant differences were found between blocked and random practice groups for accuracy, speed, or temporal evenness. At retention, the random group performed significantly faster than the blocked group, $F(1, 38) = 24.953$, $p < .001$, $\eta^2 = .92$, and the blocked group performed significantly slower than it did at the end of practice ($p < .001$). No significant differences were found between groups for transfer tasks or for attitude toward practice.

Keywords

practice, beginning band, contextual interference, blocked and random, clarinet

"When you can play it correctly three times in a row, you know you've got it!" This statement is likely to be heard in a student's private lesson or in a group band class as

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the teacher prompts her students to "try it again." However, how many students have sat in a lesson or rehearsal on the following day only to find they were unable to retain the previous day's performance? Method books recommend multiple repetitions of technical passages (e.g., Singer, 1956), practice software includes "looping" capabilities (Rodet, Roebel, Peeters, Bogaards, & Corfu, 2008), and expert musicians make extensive use of repetition in their practice (Maynard, 2006). Repetition permeates practice rooms and rehearsal spaces, yet rarely does a teacher consider that this time-honored strategy may not be the most effective means of learning for all students and in all situations (Duerksen, 1972; Green, 2006). While this strategy is often successful for adults with fully developed cognitive systems and a wealth of prior experience, it is important to examine its effectiveness with children whose cognitive systems are still developing and who have minimal playing experience.

Musicians are not alone in their endeavors to maximize the results of practice. Researchers in motor learning have invested considerable effort comparing *blocked* practice orders, when all practice trials of one task are completed before starting to practice the next task (111 222 333), to *random* practice orders, when the learner constantly switches among tasks (123 231 312). In laboratory settings, practice in a blocked schedule supported immediate performance, but practice in a random schedule was more effective for long-term learning (Brady, 2004; Lee & Magill, 1983; C. H. Shea, Kohl, & Indermill, 1990; J. B. Shea & Morgan, 1979).

The construct explaining the blocked/random paradox is termed *contextual interference,* the amount of cognitive disruption present when practicing multiple tasks. It is most often operationalized as blocked and random practice orders. Blocked practice orders cause a low level of cognitive interference because the learner is focusing on only one task for a period of time. Random practice orders cause a high level of cognitive interference because the learner must constantly redirect his or her attention to the next task. Performance analysis in contextual interference studies occurs at acquisition (the final practice trials), retention (at least 10 minute latency), and on transfer tasks (tasks similar to the practiced tasks but containing purposefully designed parameter changes). The differing levels of cognitive engagement led to the contextual interference hypothesis, which predicts that practice in blocked orders is more beneficial at acquisition but that practice in random orders supports superior learning at retention (J. B. Shea & Morgan, 1979). One theory explaining this paradox is *reconstruction* (Lee & Magill, 1983, 1985), whereby the constant switching of tasks requires cognitive movement plans to be reconstructed at each trial, thus strengthening the representation of each task. Alternatively, *elaboration* (Battig, 1966; J. B. Shea & Morgan, 1979; J. B. Shea & Zimny, 1983) would be demonstrated if random practice schedules support superior learning because the simultaneous presence of multiple tasks in working memory allows comparisons and elaborations to be made among the various tasks. The elaboration hypothesis recently has been supported by neurological findings (Lin, 2007).

Based on results of a recent meta-analysis, Brady (2004) determined that the contextual interference effect is generally reliable in laboratory settings but is less reliable in applied studies and when participants are children. Children have been found to learn effectively in both low (blocked practice) and moderate contextual interference conditions (Pigott & Shapiro, 1984; Rey, Whitehurst, & Wood, 1983). In addition, groups may perform similarly at acquisition, but at retention or transfer the random group will exhibit superior learning (Pollock & Lee, 1997; Ste-Marie, Clark, Findlay, & Latimer, 2004). Despite inconsistent results in applied settings, strong motivation remains for contextual interference research because of its potential application to teaching situations (Lee, Chamberlin, & Hodges, 2001).

Considering practice from the viewpoint of blocked and random orders is highly relevant to musicians. For example, in the common assignment of practicing three scales, should the student do all repetitions of Scale 1, then all repetitions of Scale 2, and then Scale 3 (blocked practice)? Or should the student cycle through Scales 1, 2, and 3 and then repeat that pattern several times (a form of random practice)? Questions such as these only recently have been addressed in musical contexts (Rose, 2006; Stambaugh & Demorest, 2010). Rose compared a control condition, a blocked order, and a varied (random) order for learning right-hand-lead snare drum sticking tasks by university music majors who were not percussionists. Consistent with the contextual interference hypothesis, the random group performed the most errors at the end of one practice session. However, there were no significant differences among groups at retention or transfer for rhythmic accuracy or sticking accuracy. Stambaugh and Demorest investigated the effects of blocked (changing melodies every 6 minutes), serial (changing melodies every minute), and hybrid (changing melodies every 2 minutes) practice schedules on an eight-measure melodic task. Seventh-grade clarinet and saxophone students completed one practice session and a 24-hour retention test. No significant main effects were found among groups for rhythm and pitch accuracy, musicality, or attitude toward practice condition. A significant interaction was found for musicality, with musicality scores improving from Day 1 to Day 2 for blocked and serial participants, but decreasing for hybrid condition participants.

The results of these two studies and previous motor studies raise further questions about the effects of blocked and random schedules in musical contexts. How do the length and nature of musical tasks, or participants' prior experience, interact with cognitive load? Can a framework of practice trials be used, instead of practice time, to eliminate the mini-block effects present in 1-minute practice chunks? Can the level of contextual interference be made even lower than in previous research by employing a multiple-day design? The purpose of the current study was to address these questions by examining the effects of blocked and random practice schedules during three practice sessions on performance accuracy, speed, and temporal evenness by beginning clarinet students. Based on the contextual interference hypothesis, the following assumptions were examined:

1. Students in the blocked condition will perform more accurately, faster, and more steadily than students in the random condition at the end of practice (acquisition).

2. Students in the random condition will perform more accurately, faster, and more steadily than students in the blocked condition at 24-hour retention and transfer testing.

In addition, an attitude measure was included at retention to examine differences between groups for attitude toward practice.

Method

Participants (N = 41) were beginning clarinet players recruited from 16 elementary schools in five school districts from the northwest United States. Students were enrolled in the first year of their school band programs, which started in either fifth or sixth grade, depending on the district. Students with private lesson experience on non-wind instruments were included in the study, but students with private lesson experience on the clarinet were excluded. University and school district institutional review board approvals were obtained, parents gave informed consent, and students gave assent.

I composed the stimuli to meet several constraints. Because the beginning clarinet students had been playing only for a few months, their range was limited to about one octave. The screening tasks (see Figure 1) were designed to ensure that students could play concert A, B-flat, C, D, E-flat, and F. The first practice example was composed and then transposed into two additional keys to control for potential confounds from aural aspects of the stimuli. A novel pitch, concert E, F-sharp, or C-sharp, was included in each practice example to prevent possible ceiling effects that could arise from using only familiar pitches. Four students from another beginning band program in one of the participating districts successfully completed a 4-day pilot test. Pilot students' performances did exhibit increasing accuracy and speed throughout the pilot study. Therefore, the stimuli were determined to be challenging enough and the study procedures appropriate.

Performance measures were speed, pitch accuracy, and temporal evenness. Speed was measured in hundredths of seconds from the onset of the first pitch to the onset of the last pitch, using the internal timer in Cubase software. I measured pitch accuracy through repeated listening, employing a point deduction scoring system (range: 0–7) used in a previous study (Stambaugh & Demorest, 2010): 1 point deducted for each incorrect, skipped, repeated, or added pitch, and 2 points deducted for each instance of stopping or starting over, with only the second attempt scored. A second expert judge scored 15% (534) of the trials for accuracy, and interjudge reliability was satisfactory (r = .85). The use of speed and pitch accuracy enabled analysis of the speed–accuracy trade-off, a phenomenon describing the inverse relationship between speed and accuracy in motor tasks. Generally, as a person moves more quickly, his or her accuracy toward a target will decrease (Schmidt & Lee, 2005). Parameters such as intonation, tone, and articulation were not evaluated due to the wide range of abilities among clarinet students in their first 6 months of study, as well as a desire to maintain high scoring standards by evaluating only the most salient features of beginner performance.

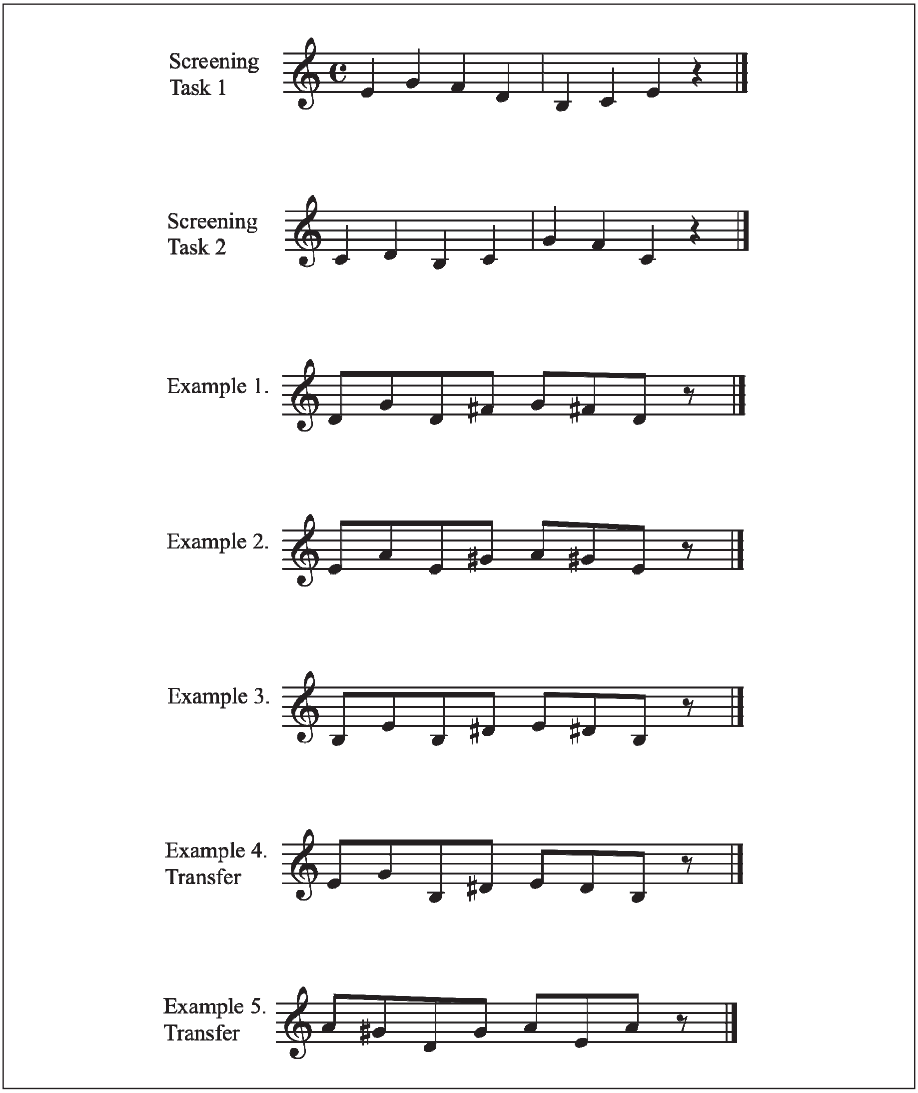

Figure 1. Performance tasks, as presented to participants
Screening tasks determined covariate score; Examples 1, 2, and 3 were played during practice Trials 1–18 (including acquisition) and at 24-hour retention; transfer tasks were played at the 24-hour retention session.

The pitches in the examples were written with the same duration (see Figure 1), permitting temporal evenness to be defined as variability of the interonset intervals (IOIs) between notes within each trial. To measure temporal evenness, the individual trials were exported from Cubase into Audacity software. The IOIs of each interval were determined to the hundredth of a second using the internal timer in Audacity. The following equations were then applied: $| IOIx - IOIm | = IOI\Delta$, $\Sigma\ IOI\Delta / \Sigma\ IOI$[1], which determined the average IOI per trial, relative to trial duration. Evenness was measured only for acquisition, retention, and transfer trials due to the time-intensive nature of such analysis.

A fourth dependent variable was attitude toward practice, which was measured by a six-statement questionnaire. Hewitt (2001) noted the importance of measuring attitude because children may choose *not* to use a practice strategy if they do not enjoy it or think it is ineffective. The questionnaire addressed three topics: (a) Did the student think his or her practice schedule was effective? (b) Would the student use that practice schedule in future practice? (c) Did the student find the practice satisfying? Each topic was stated in two items: one positive and one negative. The scores of the negative statements were reversed for generating the total attitude score. A 4-point Likert-type rating scale was selected because verbal descriptors could be generated at a fifth-grade level and 4-point scales have been used in previous practice research (Hewitt, 2001).

Design. The design was modeled after J. B. Shea and Morgan's (1979) study, which was the first investigation of contextual interference with motor tasks. Students within schools were assigned randomly to either the blocked ($n = 22$) or random ($n = 19$) practice condition. Participants began by completing a screening task; this score was used as a covariate. During one week, students completed three practice sessions and one retention testing session. In the blocked condition, participants played 18 trials of one example on each day, creating the lowest possible level of contextual interference. In the random condition, participants played six trials of each of the three examples in a random order (e.g., Example 2, Example 3, Example 1, Example 3, etc.) on each day. In both practice conditions, the final three practice trials of each example were designated as the "acquisition" score (performance ability at the end of practice). Twenty-four hours after acquisition Trials 16, 17, and 18, participants performed retention Trials 19, 20, and 21, and then three transfer trials of each transfer task.

Complete experimental designs evaluating the effect of blocked and random practice schedules also include examining potential interactions between acquisition order and retention orders. Participants in each practice group are divided and assigned to retention testing in either blocked or random orders. Given the inconsistency of previous results (Hall, Domingues, & Cavazos, 1994; Landin & Hebert, 1997; Moreno et al., 2003; C. H. Shea et al., 1990; J. B. Shea & Morgan, 1979; Ste-Marie et al., 2004), it was deemed appropriate to include this variable in the present study. Retention testing occurred 24 hours after the third practice session, with participants within each practice group randomly assigned to perform three retention trials of each example in either a blocked or random order (BB = blocked practice/blocked retention, BR = blocked practice/random retention, RR = random practice/random retention, RB = random practice/blocked retention). Assignment to the blocked or random retention order was distributed across schools and gender. The transfer trials, performed after the retention trials, were performed in a blocked order by all participants. Students completed the practice questionnaire immediately after the transfer trials. The design was fully counterbalanced.

Procedure. Students began by playing the screening tasks individually. All other sessions were conducted in groups of 1 to 7 students, depending on the number of participants per school. The students sat in a semicircle, while I was in center front, in a manner consistent with public school lesson instruction. I recorded all performance trials digitally at 16-bit 44.1 kHz sampling rate with Nady CM-60 miniature condenser lavalier microphones attached to the clarinet bell. These were connected to a PreSonus FireStudio interface into a MacBook Pro laptop running Cubase LE4 software. The use of individual microphones and multitrack recording software allowed each clarinetist's performance to be recorded as a separate track within an ecologically valid group practice setting. I led all study sessions.

At the first practice session, I introduced the novel sharp note of the first music task by the playing it on a clarinet and then displaying the fingering on a large fingering chart. I presented the fingering chart throughout all the practice and retention testing sessions. Next, students played the first example very slowly, while I observed any errors. I informed students of errors, and these were remedied before moving on to the practice phase of the session. Students practiced 18 trials on each practice day in either blocked or random order, receiving knowledge of results about accuracy in the form of verbal statements, which I gave every third trial. A 2-minute rest break occurred after 9 practice trials. Study materials did not go home with the students, and students were instructed not to practice the examples between class sessions.

Results

Accuracy and speed scores were determined for every trial performed (3,554 trials). Temporal evenness was scored for acquisition, retention, and transfer trials (1,286 trials). Scores from every 3 trials were averaged into a block (see Table 1). Tests indicated negative skew by both groups on most practice blocks for accuracy scores, and most blocks met the assumption of homogeneity of variance. Due to a linear relationship between means and standard deviations in many blocks of speed and evenness scores, these times were transformed logarithmically.

Preliminary analyses. Before testing the null hypotheses, it was necessary to determine if testing order at retention interacted with practice group. If no significant interactions were found within practice groups (BB and BR; RB and RR), these groups could be collapsed to simply blocked and random. Separate univariate ANCOVAs were completed for accuracy, speed, and evenness at retention. The a priori alpha level for each ANCOVA was set at .016 using a Bonferroni adjustment to control for Type I error (this procedure was followed for all sets of ANCOVAs listed below). The omnibus tests indicated no reliable differences in accuracy or temporal evenness, but the omnibus test for speed was significant, $F(3, 36) = 9.501$, $p < .001$, $\eta^2 = .38$. Pairwise comparisons indicated the significance was due to the between-practice group differences of BB and RB ($p = .007$), BR and RB ($p < .001$), and BR and RR ($p = .002$).

Table 1. Adjusted Means and Standard Error for Accuracy, Speed, and Evenness

	Accuracy score (0–7)		Speed in seconds		Evenness in seconds	
	Blocked	Random	Blocked	Random	Blocked	Random
	M (*SE*)	*M* (*SE*)	*M* (*SE*)	*M* (*SE*)	*M* (*SE*)	*M* (*SE*)
Block 1 (Trials 1, 2, 3)	5.48 (0.18)	5.49 (0.19)	4.37 (0.30)	5.09 (0.32)	n/s	n/s
Block 2 (Trials 4, 5, 6)	5.60 (0.20)	5.33 (0.21)	3.90 (0.29)	4.13 (0.31)	n/s	n/s
Block 3 (Trials 7, 8, 9)	5.62 (0.16)	5.43 (0.18)	3.53 (0.25)	3.61 (0.27)	n/s	n/s
Block 4 (Trials 10, 11, 12)	5.50 (0.18)	5.35 (0.20)	3.29 (0.21)	2.87 (0.23)	n/s	n/s
Block 5 (Trials 13, 14, 15)	5.49 (0.22)	5.21 (0.23)	3.51 (0.38)	2.77 (0.41)	n/s	n/s
Block 6/Acquisition (Trials 16, 17, 18)	5.47 (0.17)	5.67 (0.18)	2.92 (0.21)	2.41 (0.23)	0.16 (0.02)	0.14 (0.02)
Block 7 (Retention)	5.51 (0.15)	5.89 (0.16)	3.96 (0.24)*	2.34 (0.26)**	0.20 (0.02)	0.13 (0.03)
Block 8 (Transfer)	4.96 (0.25)	5.51 (0.27)	4.55 (0.30)	3.78 (0.33)	0.22 (0.02)	0.19 (0.02)

n/s = not scored; * = significant within group, acquisition to retention trial, $p < .001$; ** = significant between groups, blocked compared to random, $p < .001$.

Therefore, the four testing groups were collapsed into two groups and labeled by their practice condition (blocked and random) for all subsequent analyses.

Hypothesis testing. Null hypotheses were tested for each research assumption. The first assumption predicted that students in the blocked condition would perform more accurately, faster, and more evenly than students in the random condition during Blocks 1–6/Acquisition. Table 1 presents adjusted means and standard errors for both conditions in each block. Accuracy at acquisition was generally high for both groups (grand mean = 5.4 out of 7). A repeated measures ANCOVA indicated no significant main effect of trial ($p = .59$) and no Trial × Condition interaction ($p = .28$) for accuracy. Likewise, an ANCOVA for temporal evenness at acquisition found that the blocked group did not differ significantly from the random group ($p = .35$). However, a repeated measures ANCOVA on speed scores indicated a significant main effect of trial, $F(5, 34) = 5.052$, $p = .001$, $\eta^2 = .11$, with speed scores improving across trials, and a Trial × Condition interaction, $F(5, 34) = 4.346$, $p = .004$, $\eta^2 = .06$. Figure 2 shows that the blocked group averaged faster times than the random group during Blocks 1, 2, and 3. However, starting at Block 4, students in the random condition performed faster than students in the blocked condition.

The second assumption predicted that students in the random practice condition would perform more accurately, faster, and more steadily than students in the blocked practice condition at 24-hour retention testing. Repeated measures ANCOVAs from acquisition to retention indicated no significant main effect of trial ($p = .25$)

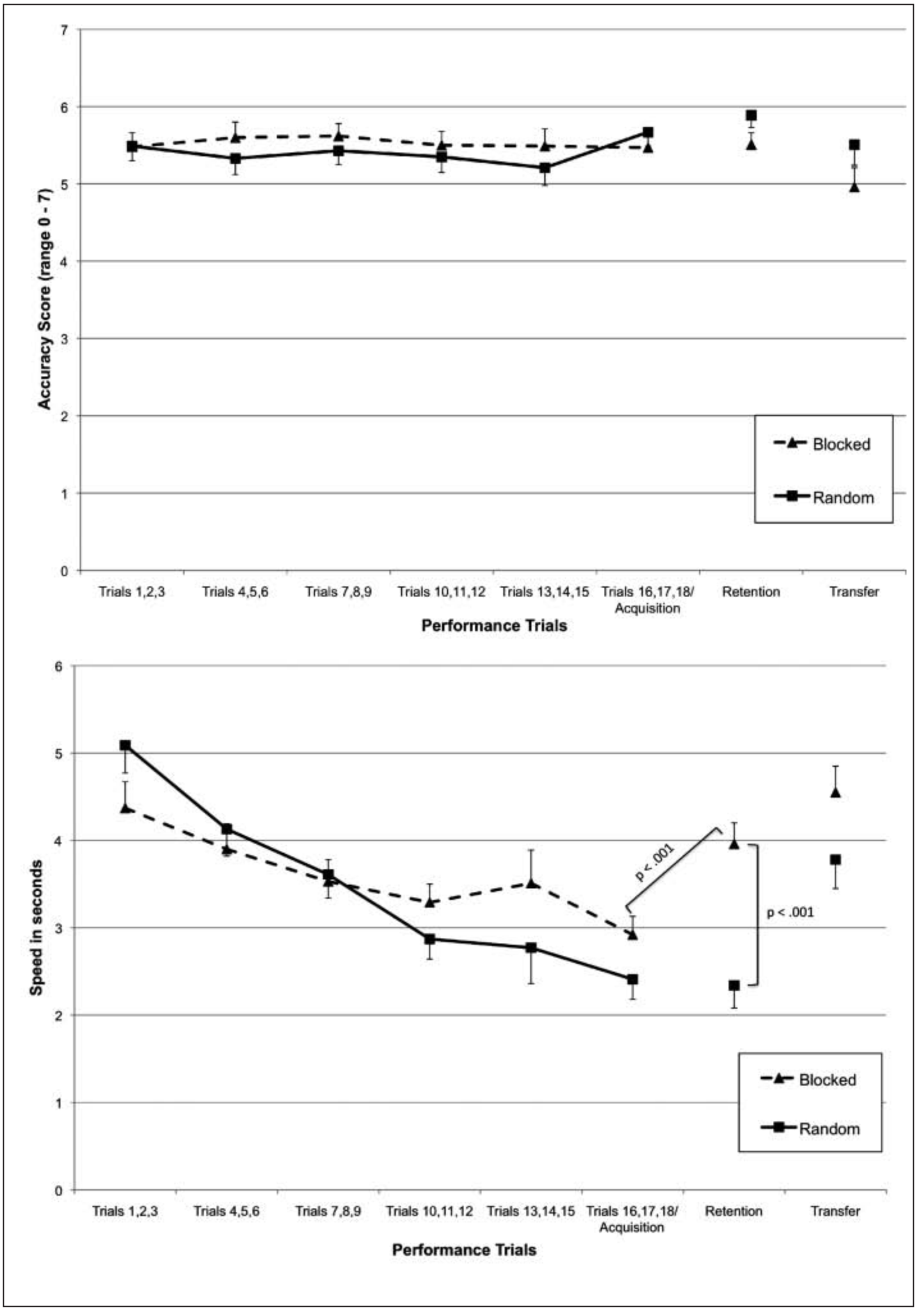

Figure 2. Adjusted means and standard error for accuracy and speed
Source: Data points represent the average of three trials.

or Trial × Condition interaction ($p = .44$) for accuracy nor for temporal evenness (trial, $p = .47$; Trial × Condition, $p = .06$) or for speed (trial, $p = .22$). Despite stability in accuracy and temporal evenness scores, however, a significant Trial × Condition interaction was found for speed, $F(1, 38) = 24.953$, $p < .001$, $\eta^2 = .92$. Students in the random condition played significantly faster than students in the blocked condition at the retention stage, and the effect size was strong. Furthermore, pairwise comparisons indicated that students in the blocked condition played significantly slower at retention than they did at acquisition ($p < .001$). The second assumption also predicted that students in the random condition would exhibit superior performance on transfer examples. Repeated measures ANCOVAs for Block 6/Acquisition and Block 8/Transfer on accuracy, speed, and temporal evenness scores indicated no main effects of trial (accuracy, $p = .79$; speed, $p = .24$; evenness, $p = .90$) and no Trial × Condition interactions (accuracy, $p = .36$; speed, $p = .78$; evenness, $p = .88$).

The results of the attitude questionnaire were examined at the descriptive level, due to the limited number of survey items. Participants in both groups responded positively to their practice conditions: blocked, $M = 3.03$, $SD = .43$; random, $M = 3.18$, $SD = .49$.

Discussion

The purpose of this study was to examine the effects of blocked and random practice orders in the ecologically valid setting of group beginning band instruction. There were no performance differences between groups at the end of three practice sessions. However, 24 hours after completing practice, random group participants were able to play significantly faster than blocked group participants without sacrificing accuracy. Performance speed by the blocked group participants actually deteriorated to the level of early practice trials. Participants in both groups expressed a positive attitude toward their practice conditions.

The contextual interference hypothesis predicted that the blocked group would perform better at acquisition but that the random group would perform better at retention. Results of this study provide partial support for the second half of this hypothesis, because the random group did perform faster at retention. These findings are consistent with other applied studies with adults practicing badminton (Goode & Magill, 1986), baseball (Hall et al., 1994), and basketball (Landin & Hebert, 1997), as well as children practicing handwriting (Ste-Marie et al., 2004) and beanbag tossing in laboratory (Edwards, Elliott, & Lee, 1986; Pollock & Lee, 1997) and real-world settings (Baker, 2002; Pigott & Shapiro, 1984). However, unlike the contextual interference hypothesis, the extra challenge of random practice schedules did not moderate the random groups' performance at acquisition. Ste-Marie et al. recognized this pedagogical significance, noting it "implies that a child can maintain the same level of performance even when exposed to what might seem to be a more difficult task" (p. 124).

Several alternatives could explain the divergence between the classic contextual interference hypothesis and the present results. First, unlike laboratory studies, the motor task for this study was an applied task of a musical nature. Variables in applied studies cannot be controlled as carefully as in laboratory studies (Brady, 2004). Regarding the musicality of the task, the stimuli were designed specifically to begin and end on tonic pitch. Students cultivated an aural imprint of the task, and as automaticity progressed, it is possible that this aural component facilitated a pitch-to-finger mapping that is not possible in nonmelodic tasks.

Another possible explanation for the similarity between group performances at acquisition is differences between single-day practice designs (e.g., Rose, 2006; J. B. Shea & Morgan, 1979) and 3-day practice designs. In single-day designs and in the blocked group in this study, Block 6/Acquisition occurred on the same day as all practice trials: there was no sleep-based consolidation interval (Davis, 2009; Duke, Davis, Allen, & Goins, 2006). However, the random groups in the current study and in Landin and Hebert's (1997) study distributed their practice on each task over 3 days, allowing some consolidation to occur during the first and second nights prior to Block 6/Acquisition. This early consolidation may have overcome the initial benefit of blocked practice. Duke and Davis (2006) investigated how sleep-based consolidation affected participants' learning of two motor tasks (silent piano, five-note sequences) during the same practice session, finding that performance of both tasks improved significantly following overnight sleep. While those participants practiced only two tasks, and the participants in the current study practiced three tasks, Duke and Davis's findings suggest that more than one task may benefit from sleep-based consolidation.

After practicing in either the blocked or random order, students in these groups were tested in either a blocked or random order. J. B. Shea and Morgan (1979) found that university students who practiced in a blocked order performed significantly slower when tested in a random order than when tested in a blocked order. For those adults, the mismatch between encoding and retrieval significantly affected performance. However, like Ste-Marie et al. (2004), I found no significant differences for accuracy, speed, or temporal evenness within practice conditions by children who were tested in random or blocked orders at retention. This is of interest because a random order is often more similar to actual musical performance than a repetitive order is.

The ability to balance speed and accuracy reflects how skillful one is in performance (Drake & Palmer, 2000). The clarinetists were given the directions, "Perform as *accurately* [verbal emphasis added] and quickly as possible," placing a priority on playing the correct pitches before attempting to play faster. Students did maintain high accuracy standards throughout the practice sessions while improving their speed. Although this finding is contrary to motor learning research, it is consistent with other music–motor studies involving piano tasks (Palmer & Meyer, 2000; Palmer & van de Sande, 1993; Simmons & Duke, 2006). A possible motor explanation for this discrepancy is found in the results of Langolf, Chaffin, and Foulke (1976), who suggested that smaller limbs, including fingers, were less susceptible to task difficulty than larger limbs like arms. Alternatively, a musical factor such as maintaining the melodic integrity of the pitch sequence also could be a key factor to musicians' preservation of accuracy. Investigations of beginning instrumentalists' practice and performance demonstrate that this concern for pitch starts early, as McPherson and Renwick (2001) found that beginners attend to pitch before rhythm to a large degree.

The results of this study indicate that there may be a modest or selective learning advantage for beginning clarinet students practicing in a random order, but Rose (2006) found no differences between groups of college students practicing snare drum sticking. There were many differences between these two studies, including ages of the participants, number of practice sessions, retention delay, and aural nature of the musical task. In addition, the clarinet task was essentially a fine motor skill with the primary degrees of freedom in the fingers. The snare drum task was more similar to a gross motor skill, with the primary degrees of freedom in the wrist and/or elbow joints. Because there is only one other applied study of blocked and random practice schedules with a fine motor skill (Ste-Marie et al., 2004), it is not yet known if that alone could account for different results between these musical tasks.

The practice orders implemented in this study could be considered a form of structured practice. Structured practice, which involves using a planned sequence of practice activities, has been found to be beneficial for students of all ages (Barry, 1990, 1992; da Costa, 1999). Because this study did not include a control group, it is not known how these results would compare to the progress students might make during their own free practice sessions. Rose (2006) included a control group to compare to her blocked and random practice groups, finding that both the blocked and random groups performed similarly to the control group for sticking accuracy but that the control group performed less accurately on rhythm.

Implications and Recommendations for Music Education

Results of this study demonstrate that repetitive practice may not always be the most effective strategy for beginning musicians. Teachers could structure class instruction using random orders, rather than relying exclusively on repetitive drill, and teach students how to structure their home practice in this way. For example, having identified three short pitch sequences within a longer melody, teachers would direct individuals or groups of students to play the sequences in a random order. The teacher could call out which sequence to play, students could choose the random order, or if SmartBoard technology is available, it could generate an order. It is important to note that this recommendation is a very specific practice strategy that is being suggested for use with short pitch sequences that pose technical challenges. When a similar strategy was investigated previously (Stambaugh & Demorest, 2010) using eight-measure songs, no significant differences were found among groups for pitch or rhythm accuracy. In order for beginning students to use a specific practice strategy, they must be able to self-regulate their practice. Many descriptive studies have shown that beginners make very limited use of self-regulated practice strategies (Austin & Berg, 2006; Hallam, 2001; McPherson & Renwick, 2001; Pitts, Davidson, & McPherson, 2000). Therefore, it would be critical for teachers to help students make this application at home. This isolation of particular technical challenges may encourage the development of effective "analytical" practicers (Rohwer & Polk, 2006).

Although the results of this study apply only to a specific instrument, student level, and nature of musical task, they invite researchers to examine random practice schedules in other musical contexts. Blocked and random practice schedules manipulate the cognitive load present during practice. Therefore, it would be interesting to examine this impact with other instruments, especially in the brass and violin families, that may place greater cognitive demands on performers. Because cognitive abilities change across a lifetime, age may have a significant influence on the effects of practice schedules. Likewise, experience also has been shown to be a critical factor in applied motor learning studies. It would be worthwhile to include musicians at the high school, college, professional, and amateur adult levels in future studies. Other group designs could include a blocked schedule of 1111 2222 3333 each day, controlling for consolidation effects because both groups would be practicing the same tasks an equivalent number of trials on each day. Finally, blocked and random schedules should be compared with a control group schedule to ascertain how the performance improvements seen here would compare to improvements that students would have made in their usual practice.

Researchers in this area need to select carefully the musical tasks participants will practice. The number of specific pitches in the tasks needs to be considered, because motor learning tasks should represent a task that can ultimately be thought of as a unit. In addition, a critical factor for designing control group procedures will be determining the duration of practice: How will the researcher match the practice *trials* in blocked or random practice orders to a *time* measure (or some other measure) in a control setting?

In this study, I investigated an alternative to traditional, repetitive methods of practice. Instrumental practice has been investigated primarily from the assumption that what experts do is what learners at all ability levels should do. Since most beginners are significantly younger than experts, questioning this assumption is a valid concern. In addition, arming beginning band teachers with specific recommendations for their first-year students' practice may enable students to be more efficient and effective in their practice.

Author's Note

This article is based on the author's dissertation, "Effects of Blocked and Random Practice Schedules on Performance by Beginning Wind Players," completed at the University of Washington in 2009.

Declaration of Conflicting Interests

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Note

1. For each trial, the average interonset interval (IOI) of the six intervals was determined (IOI*m*) and subtracted from the IOI of each individual interval (IOI*x*) in the trial. This produced six scores for the differences between individual IOIs and the mean within the trial. The sum of all difference scores ($\sum$ IOIΔ) was divided by the sum of the IOIs for the trial ($\sum$ IOI).

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Bio

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