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When less of the same is more: Benefits of variability of practice in pianists

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Variability of practice has been demonstrated to have beneficial effects for motor skill acquisition, transfer, and retention. This study extends the line of research to musical practice. Pianists were trained to perform a wide interval leap on the piano with their left hand. Performance at the target distance was tested before and after a 30-minute controlled training. One group (FIX) practiced the target interval only. The other group (VAR) received variable training on four different intervals including the target. Transfer was tested on an interval novel to either group. Retention was assessed in a retest 24 hours later. Leap Distance Error (LDE) and Leap Execution Time (LET) were measured. After training, LDE improved non-significantly in both groups. In the VAR group significant improvement was seen on the next day. This was not the case in the FIX group. In contrast to the FIX group, the VAR group showed significantly faster LET after training compared to baseline, which was stable at retention. The findings are discussed with regard to predictions made by theories of motor learning and implications for musical practice.

Keywords: variability of practice; piano; motor skill acquisition; musicians; schema theory

Playing music is a difficult motor skill orchestrated by goal-directed movements. Findings from motor learning research may be applicable to instrumental practice. Schmidt's "schema theory" (1975) formulates a schema as an abstract code for a class of movements with a common pattern. Schema learning is the gradual formation of a central prototype from a number of specific experiences within a motor class. The *variability of practice* (VOP) hypothesis predicts that practicing a particular skill under variable, as opposed to constant, conditions builds a more effective generalized motor program. This would be reflected accordingly in superior learning, retention, and transfer compared to constant learners. Shea and Zimny (1983) suggested that variability effects were due to *contextual interference* (CI), which may be (1) emphasized by inter-trial elaboration and distinctive processing of representations in memory (Shea and Zimny 1983) or (2) an increase in effortful processing activity (Magill and Hall 1990). The CI hypothesis, like the VOP hypothesis, predicts better transfer and retention but poorer performance (in variable compared to fixed learners) during the initial acquisition phase.

McCracken and Stelmach (1977) presented a task involving time-constrained hand movements to targets at defined distances. The training phase consisted of 300 trials on four randomly alternating distances for one group, and of 300 trials on just one distance for another group. Our aim was to utilize a similar leap motion (musical interval on a piano) in musicians in order to test whether or not the predictions made from VOP and CI apply to musical practice.

METHOD

Participants

Twenty right-handed music students took part in the experiment (9 female, age 20.5±2.2 years). All participants studied piano as their minor subject, a choice made in order to avoid ceiling effects. Demographic information, handedness, practice habits, and musical biography were obtained through a questionnaire. Participants were randomly assigned to one of two experimental groups.

Materials

The experiment was performed on a digital piano. The tasks were presented as musical notation via a monitor. Performance data were collected via MIDI interface. Statistics were analyzed using SPSS (IBM).

Procedure

The core task for the pianists was to train to perform a wide interval leap on the piano with their left hand. At both starting and end position of the leap, two notes at an octave distance were played by the thumb and fifth finger respectively. In the time domain, the training goal was to execute the metronome-guided leap in 187.5 ms (as a semiquaver at 80 bpm per quarter note).

Both groups exercised a 190-trial standardized computer-interactive training session. One group of participants (FIX) practiced the target interval only (spanning 15 semitones, i.e. a musical minor tenth). The other group (VAR) received variable training on the diatonic intervals of 8, 12, 15, and 22 semitones, thereby spending only 25% of their trials on the actual target interval. The intervals were presented in small blocks of five trials each and the block order was randomized. For either group, the first (PRE) and the last (POST) fifteen trials of the training sessions, respectively, consisted of target trials only. A novel transfer task was administered following the completion of training; in this case, a diatonic 19-semitone leap.

Following a 24-hour period without further exposure to the instrument, retention (RET) on target and transfer intervals was tested. Performance measures were Leap Distance Error (LDE) and Leap Execution Time (LET). Comparisons were carried out using Mann-Whitney (between-subjects) and Wilcoxon (intra-subject) tests and Holm-Bonferroni corrections for multiple comparisons. Global alpha was set at 0.05.

RESULTS

Leap Distance Error

LDE (see Figure 1, left) improved non-significantly in both groups (FIX: PRE median=0.44 semitones off-target, min=0.1, max=1.4; POST 0.31, 0.13, 0.83; VAR: PRE 0.51, 0.27, 0.94; POST 0.35, 0.00, 0.78). In the RET data, significant improvement was seen compared to PRE for the VAR group (0.35, 0.10, 0.61; $p=0.037$, Wilcoxon), while in the FIX learners the RET performance (0.41, 0.14, 1.14) did not differ significantly from the PRE-training baseline. For transfer conditions, no significant differences compared to PRE were found in either group after training and at retention (medians: POST: VAR 0.34, 0.08, 0.71, FIX 0.32, 0.23, 0.61; RET: VAR 0.36, 0.11, 0.66, FIX 0.40, 0.14, 0.77).

Leap Execution Time

For LET (see Figure 1, right), the VAR group improved their LET from 277 ms (214 ms, 378 ms) at PRE to 238 ms (217 ms, 272 ms) at POST ($p=0.021$, Wilcoxon). The effect was stable at RET (243 ms, 219 ms, 286 ms; $p=0.026$, Wilcoxon). The FIX group showed no significant changes (PRE: 267 ms, 228 ms, 404 ms; POST: 233 ms, 209 ms, 482 ms; RET: 254 ms, 224 ms, 341 ms). For transfer conditions, no significant differences compared to PRE were found in either group (POST: VAR 257 ms, 218 ms, 318 ms, FIX 260 ms, 214 ms, 456 ms; RET: VAR 255 ms, 218 ms, 302 ms, FIX 272 ms, 224 ms, 344 ms).

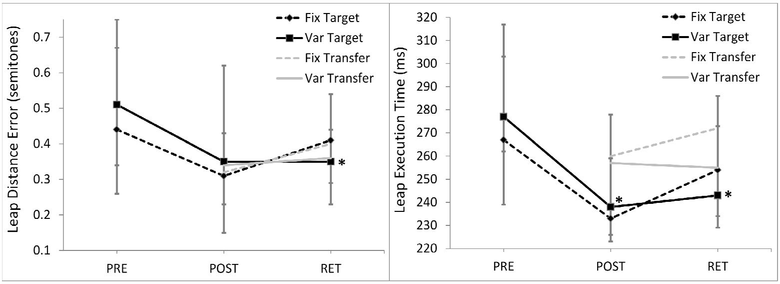

Figure 1. Group medians of LDE (left) and LET (right) for the groups VAR (solid lines, N=10) and FIX (dashed, N=10); before (PRE) and after (POST) training, and after 24 hours (RET). The grey lines indicate performance at a transfer task for the respective groups/sessions. Error bars represent upper and lower quartiles. *$p<0.05$ (Wilcoxon) compared to PRE.

DISCUSSION

The overall results of the present study are consistent with Schmidt's (1975) *variability of practice* hypothesis. However, a *contextual interference* effect could not be observed; rather than showing an initially worse performance than the FIX group at the end of the acquisition phase, the VAR group performed similarly well for the reported performance measures.

The advantages of variable learning over fixed learning in this specific paradigm can be summarized as follows: after training, learners who underwent a variable practice schedule showed no disadvantages with respect to accuracy and timing precision compared to constant learners. This is worth highlighting insofar as their number of different content items, acquired within the same amount of practice time, was *four times as high* compared to constant learners. With respect to accuracy and timing precision, variable learners *consolidated* their skill into a stable representation more successfully than constant learners.

One reason why several of the within-subject and between-group differences were not significant (besides the small sample size) may be attributed to the limited impact of a single and short training session. In the motor learning literature, interventions typically last up to several weeks. Although for the training of more complex sequences at the piano, some training effects within a single session have been demonstrated for novices (Bangert and Altenmüller 2003). The outcome from a single session in advanced piano students, however, may not represent a typical scenario of rehearsing music.

While the present results indicate possible advantages of variable learning for long-term consolidation in the task investigated here, constant learning is known to provide superior results in other contexts. Various empirical accounts have indicated that the complexity of a task is of crucial relevance (Wulf and Shea 2002). As complexity increases, learners seem to benefit more from the opportunity to repeat and refine their responses on successive trials. As a consequence, CI tends to be reduced or eliminated with more complex tasks. Musical movement sequencess are more complex than the task in the present study. However, an additional advantage of VOP may be motivation. Because variable learners are frequently changing tasks, practice may seem less repetitive, potentially increasing the level of engagement. A higher diversity within practice schedules may give learners a larger "workspace" (Davids *et al.* 2001), keeping them motivated and encouraged (Simon and Bjork 2001). However, this issue has not been addressed in the present study.

Building upon the present findings, further research can extend and complement the paradigm in a number of ways. As elaborated above, the degree of complexity is an important parameter which can be systematically varied on the piano. Another interesting option might be to design transfer paradigms that involve the transfer of a unimanual motor skill to the "naïve" contralateral hand.

We conclude that variability of practice might be advantageous over constant practice in specific contexts of musical practice.

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