Effects of Early and Late Rest Breaks during Training on Overnight Memory Consolidation of a Keyboard Melody

Robert A. Duke, a Sarah E. Allen, b Carla D. Cash, c and Amy L. Simmons d

a Center for Music Learning, The University of Texas at Austin, Austin, Texas, USA
b Meadows School of the Arts, Southern Methodist University, Dallas, Texas, USA
c School of Music, Texas Tech University, Lubbock, Texas, USA
d Institute for Music Research, The University of Texas at San Antonio, San Antonio, Texas, USA

In two experiments, we tested the extent to which overnight procedural memory consolidation is affected by extended rest breaks during training. In the first experiment, nonmusicians practiced a 5-element keypress sequence with their nondominant hand in 12 30-s practice intervals separated by 30-s pauses. In the second experiment, nonpianist musicians practiced a 13-note keyboard melody using the same procedures. In both experiments, approximately one-third of the subjects took a 5-min break after the first three blocks of practice; another third took a break after nine blocks of practice; the remaining participants did not take an extended break. All were trained in the evening and were retested the following morning. Participants in both experiments made dramatic improvements over the course of the training and retest sessions, and participants who took an extended rest break early in practice made the largest gains in performance between the end of training and the beginning of retest.

Key words: learning; procedural memory; consolidation

Research into the effects of sleep on procedural memory consolidation has demonstrated that learners performing repetitive movement sequences show evidence of consolidation-based performance enhancements after overnight sleep. More recently, it has been determined that extended rest periods interposed during the training of sequential motor skills lead to short-term enhancement of skill performance after the rest interval, a phenomenon called reminiscence, which has been studied extensively in the context of pursuit rotor tasks (see Eysenck and Frith for a review).

In previous investigations in our group, we found that nonmusician learners who practiced a 5-element keypress sequence on a digital piano keyboard showed evidence of consolidation-based enhancements in performance accuracy and speed following 12-h intervals that included overnight sleep, a finding consistent with a great deal of previous research (see Stickgold and Walker for a review). We observed similar effects among experienced musicians performing keyboard melodies, indicating that consolidation-based enhancement of procedural memories extends to musical tasks.

In the two experiments reported here, we show that the extent of overnight performance enhancement is affected by taking extended rest breaks during practice, and that extended intervals of rest early in training, rather than producing only temporary improvements in performance, lead to increases in
consolidation-based enhancement overnight. In the first experiment (reported previously), 36 right-handed nonmusicians performed a 5-element finger-tapping sequence with their left hand, using the keys F3, G3, A3, and B3 on a full-size digital piano with fully weighted keys (simulating the action of an acoustic instrument). The sound of the keyboard was turned off. During evening training sessions, subjects practiced the sequence 2-5-3-4-2 (numbers indicate traditional piano finger numbers; i.e., 2 represents index finger, 3 represents middle finger, and so on) with the goal of playing “as quickly and accurately as possible.” Practice was organized in 12 30-s practice blocks separated by 30-s pauses. One-third of the subjects took a 5-min rest break after the first three blocks of practice; another third took a break after nine blocks of practice; the remaining subjects did not take an extended break. Approximately 12 h later, following a night of sleep, subjects were retested in six 30-s blocks separated by 30-s pauses, with a 5-min rest interval between the third and fourth blocks of retest.

We measured performance in terms of the number of correct key presses per block (CKP/B), a measure that takes into account both the speed and accuracy of subjects’ skill, and we analyzed the rates of improvement across the study period by comparing the mean...
CKP/B difference scores between consecutive 3-block triplets (Fig. 1).

The introduction of extended rest in the early and late stages of practice significantly affected the rates of learning within and between sessions. Results show that the magnitude of the difference scores varied over the course of the learning and retest periods, $F(4, 132) = 31.05, P < 0.001$. Though the magnitude of the performance gains did not differ among groups overall, $F(2, 33) = 2.26, P > 0.12$, a significant interaction indicates that subjects were differentially affected by the placement of rest intervals during training, $F(8, 132) = 4.198, P < 0.001$. Immediately after the 5-min rest intervals, subjects in both the early-rest and late-rest conditions showed large gains in CKP/B, a finding consistent with other research on reminiscence effects. But only after the early rest did subjects continue to show improvement across the next two blocks of practice and, importantly, subjects in the early-rest group also showed the largest gains in CKP/B overnight.

In a second experiment, we tested whether highly skilled musicians would show evidence of similar consolidation-based enhancements in the performance of (audible) music. The target task in this experiment was a 13-note keyboard melody (Fig. 2), which 48 nonpianist musicians practiced with their nondominant hand using the same procedures described above. Nonpianist music majors enrolled in undergraduate and graduate programs participated in the study. All subjects had taken no more than four
semesters of group piano instruction and had received no more than 3 years of private piano lessons.

Here too subjects made dramatic improvements in the number of CKP/B over the course of the evening training and morning retest sessions, and the magnitude of the improvements varied across the study period, $F(3.3,172) = 7.01, P < 0.001$. There were no differences among conditions overall, $F(2,43) < 1, P > 0.88$, but again subjects who took an extended break early in practice made the largest gains in performance between the end of evening training and the beginning of morning retest, although the interaction between condition and difference score did not reach statistical significance, $F(6.6, 172) = 1.61, P < 0.14$ (Fig. 3). Subjects who took a late break showed no evidence of overnight enhancement, and subjects who took no extended break showed a small overnight enhancement, which is also consistent with the results of the first experiment.

The time course of procedural memory consolidation remains to be fully characterized, and our finding that performance during training shows a sustained increase after short early breaks raises questions about differential effects of rest intervals that depend on the timing of rest in a given training session. It may be that early breaks during the initial phases of motor sequence learning allow time for the neurophysical processes that underlie consolidation to engage, and that after extended intervals of rest early in initial training sessions, the encoding of new procedural memories is in some way advantaged. This effect has been studied in only a few investigations to date, but the preliminary findings are interesting and certainly warrant further examination.

References