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# Commentary: Generalization of procedural motor sequence learning after a single practice trial

Fumiaki Iwane[1]*, Brian Johnson[2], Leonardo G Cohen[1]

[1]Human Cortical Physiology and Neurorehabilitation Section, NINDS, NIH, Bethesda, MD, USA
[2]Department of Occupational Therapy, School of Medicine, Washington University in St. Louis, St. Louis, MO, USA

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***Correspondence:**
*Dr. Fumiaki Iwane, Human Cortical Physiology and Neurorehabilitation Section, NINDS, NIH, Bethesda, MD, USA; Email: fumi.iwane@nih.gov



Learning to perform a new skill is part of our daily living activities. Most daily skills, like playing the piano or practicing sports, requires precise performance of sequential motor actions[1]. When we learn a new skill, initial performance improvements become evident predominantly during rest rather than during practice intervals[2,3]. These micro-offline performance improvements during early skill learning are thought to reflect a rapid, wakeful form of consolidation of skill[2,3].

To learn a new skill we may profit from previous knowledge of different but related tasks[4,5]. Generalization refers to the situation in which previous knowledge aids learning of a new skill[4,5]. For example, performance of a skill over long periods of time (e.g., days or weeks) can facilitate new skill learning[6-8]. Generalization has been reported following periods of training across limbs, from right to left hand[7,8], from eye to hand[6-9] and across memory tasks[10,11]. Less is known about generalization developing after only seconds of practice of a skill and particularly over practice (online) and rest (offline) intervals that characterize early skill learning.

Johnson et al.[12] recently addressed this question. 2,095 participants were recruited to perform an online study of generalization of early skill learning. Subjects practiced two new skills (A and B) over periods of 10 s separated by rest intervals of equal duration. The two skills shared ordinal (matching keypress locations), transitional (order of keypress pairs), "parsing rule" (i.e., repeated keypresses used as a breakpoint for segmenting the sequence into smaller units or chunks) structures or had no similarities. The overall question was how and if a brief practice period of a sequential skill A (seq A) influence performance and learning of a different sequential skill B (seq B).

In the first experiment, participants practiced seq A (digit keypresses 4-1-3-2-4 performed on a keyboard) for varying number of trials (1, 2, 5 or 12 trials). They were then tested on their ability to perform and learn a different seq B (2-3-1-4-2). The duration of practice and rest intervals were 10 s. The endpoint measure was typing speed [correct sequences/second, seqs/s]. The main findings were that (a) Initial seq B skill was superior to seq A skill at the end of the previous practice trial and (b) this form of generalization developed during the single rest interval separating seq A and B (micro-offline gain). Two aspects of seq A structure generalize to seq B: (a) the sensorimotor transformations required to type keypresses, common to both skills; and (b) the parsing rule structure, also common to both skills.

A single practice trial of skill A resulted in generalization of the parsing rule shared between the two skills. Lengthening the practice

duration of seq A or lengthening the rest interval duration following a single trial of seq A did not modify this form of generalization. Finally, sharing of ordinal or transitional similarities between the two 5-keypress sequence skills did not induce significant 1-trial generalization (Figure 1). The conclusion from these experiments was that distinct features of skill sequence structure can generalize very rapidly during early skill learning. Neural replay in hippocampus-neocortical regions is thought to support formation of abstract relational structure between motor states described here[13].

The authors propose that more work is needed to study longer sequences, with various levels of "complexity"[14,15] and higher applicability to tasks of daily living along the lifespan. Understanding generalization of skill would be important to develop more effective tools to teach skills and sports in healthy individuals and neuro-rehabilitation after brain injuries.

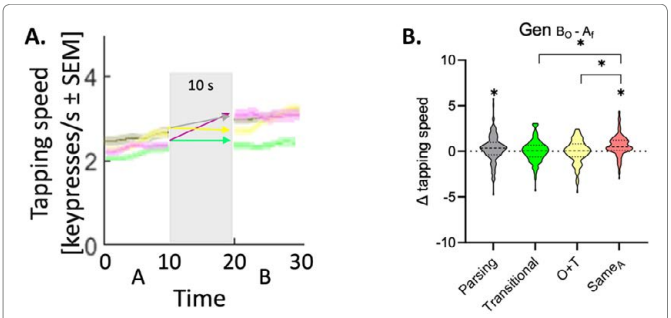


**Figure 1**: Generalization of Skill after a single practice trial.
**A)** Performance in the first trial of the same skill A and different skill Bs. (grey: PARSING; green: TRANSITIONAL; yellow: ORDINAL + TRANSITIONAL (O + T); purple: SAME as skill A ($Same_A$); mean ± SE, different groups). Note the similar performance in skill A across groups but different performance in skill B. Specifically, the highest generalization occurred when sequence B was the same as A (pink, $Same_A$), followed by the PARSING sequence (gray). **B)** Change in performance from the end of skill A to the onset of skill B was highest in the $Same_A$ group. This performance gain was significantly greater than TRANSITIONAL and O + T.

## Declaration

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