Exploring a Novel Training Paradigm for Knowledge and Skills Acquisition

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Introduction

Due to the importance of training, many scientists have studied effective training schedules, and they have compared distributed practice schedules to massed practice schedules. Most of the results consistently show that a distributed practice schedule outperforms a massed practice schedule in a retention test, because of the spacing effect in human memory.

This result may lead new scientists who want to investigate knowledge and skills acquisition to explore just these two schedules and compare them in retention tests without examining other options. However, I think that we need to consider and approach another way for knowledge and skills acquisition. According to Anderson's (1982, 1993) ACT-R theory, skill acquisition is the process of transition from declarative memory to procedural memory, and in the fully procedural stage, human beings do not need to retrieve their declarative memory to implement a task, even if they forgot the knowledge in declarative memory, they can perform the whole task without any errors. Based on his findings and theory, the most important factor in learning is how to transform learned knowledge to the procedural stage of the learning framework, and the research for learning should not compare two relatively extreme schedules, but make an appropriate schedule that could transfer learners to the procedural stage for each piece of knowledge. In this paper, I will present a candidate approach to make an appropriate schedule for getting better performance in knowledge and skill retention, and as a doctoral consortium paper, I hope I have useful advices for theoretical approach of the ACT-R cognitive architecture in this topic.

Theory

Spacing effects exists in human memory. This explains the reason that a distributed practice schedule has better performance than a massed practice schedule in retention tests. However, I mentioned in previous section, research for training should be focused on how to transfer a learned skill to the procedural stage.

Unfortunately, we do not have any measurement whether learners are in the procedural stage or not. One of the candidate measurements could be differences between the performances of the last training session and the retention session, however, it is difficult to fix the amount of differences that could represent the procedural stage. So, I think that we should consider how to increase performance in retention, and it may the only way to approach for explaining the status of procedural stage.

Pavlik (2005) studied practice and forgetting effects on vocabulary. In this research, he found that the spacing effects could be increased through distributed practice with massed practice; in other words, a mixed schedule could produce better performance than distributed schedule in vocabulary memory task.

I also think some kinds of tasks, such as procedural or perceptual-motor tasks, may show even better performance through an initial or distributed massed practice schedule. For example, we can learn how to ski perhaps better not in a distributed way (1 hour per day over 5 days), but in massed way (5 hours in a row in one day).

From the above results, I argue that a hybrid practice schedule that is a mixed schedule including distributed and massed practice, could increase the spacing effect, and generate better performance than a purely distributed or massed practice schedules on the retention test.

Methodology

To explore the better schedule on retention test, four kinds of experiment environment were developed. These tasks are presented in Table 1.

Table 1: Four tasks with respect to knowledge type.

Knowledge Type	Task
Declarative Memory	Japanese Vocabulary
Procedural Memory	Tower of Hanoi
Procedural to Declarative	Permutation Problem
Perceptual-Motor	BalanceMe® Game

The Japanese Vocabulary test that is similar to the task of Pavlik and Anderson (2003, 2005), is a web-based test, and participants will be tested with 15 Japanese vocabulary words. The accuracy (the number of correct answers) and RT (the completion time per correct answer) will be measured.

There are two kinds of tasks in procedural memory type. One is the Tower of Hanoi puzzle, and the other is solving permutation problem. A Tower of Hanoi game that will be modified from its original style has 3 rods with 6 disks. Participants will be asked to move 6 disks from the leftmost rod to the rightmost rod. The number of movements and the duration time will be measured.

For the permutation problem test, I will use the task of Rohrer and Taylor (2006). Participants will be taught to solve the number of unique ordering (or permutations) of a letter sequence with at least one repeated letter, such as

aabbbb, aabbbcc, etc.;, 12 problems will be presented. The accuracy (the number of correct answers) and RT (the completion time per correct answer) will be measured.

The BalanceMe® game, an Iphone® Application, will be used for the perceptual-motor task. This is very similar to an inverted pendulum. Participants will be asked to keep balancing the stick in the screen by tilting the device. The time duration of balancing will be measured.

Participants will be divided into 3 groups, massed group, distributed group, and hybrid practice group, and they will be asked to perform 8 sessions for training and 1 session to test retention. Each session consists of 4 tasks, and the order of tasks will be decided randomly.

Expected Results

As I mentioned in the Theory section of this paper, I assume that the participants of hybrid practice may show the best performance in all four tasks of retention test. The reason is that I believe the hybrid practice including the distributed practice and massed practice could increase spacing effect in human memory. I expect that the distributed practice schedule may outperform massed practice schedule in declarative memory task and the procedural to declarative task, because learners mainly depend on their declarative memory in these kinds of tasks. However, massed practice schedule may outperform distributed practice schedule in procedural memory task and perceptual-motor task, because massed practice may be needed in these kinds of tasks. These expected results are presented in Table 2. Figure 1 and figure 2 present expected learning curves of each of these practice schedules.

Table 2: The expected results for each task.

Schedules	Task
H > D > M	Japanese Vocabulary Permutation Problem
H > M > D	Tower of Hanoi BalanceMe® Game

Note: H means Hybrid, D means Distributed, and M means Massed Practice.

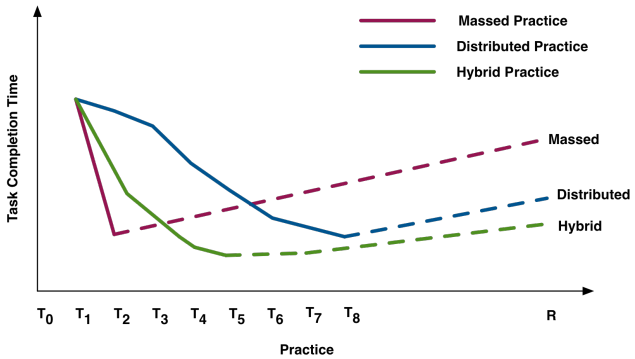

Figure 1: Expected results for declarative memory task and procedural to declarative task.

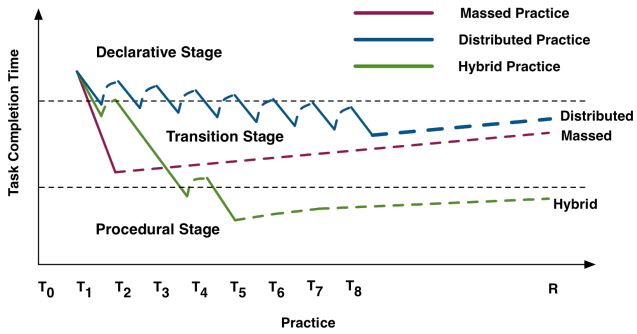

Figure 2: Expected results for procedural memory task and perceptual-motor task.

Conclusions

In this paper, I present a hybrid practice schedule that includes distributed and massed practice, and I assume that this is one of the candidate practice schedule for transferring learners to the procedural stage of learning framework. To explore this, I created four kinds of tasks that represent different knowledge types, declarative, procedural, and perceptual-motor.

At least 30 participants, 10 for each schedule, will be recruited by 31 July 2010, and I will explore the candidate hybrid schedule based on the ACT-R theory. By comparing human data and the theory of ACT-R, I may verify or extend the theory. Finally, this experiment will show the learning curves with the same subject in different types of tasks.

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