EFFECTS OF PRACTICE AND PRACTICE SCHEDULES ON THE DEVELOPMENT OF AUTOMATICITY – A DUAL-TASK STUDY

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The proposed research project consisted of four specific aims. This final report summarizes the findings of each specific aim. I have presented the results in abstracts formats in multiple conferences and three manuscripts are currently under preparation for submission. The end of the report listed all published and to be published abstracts or manuscripts generated from this project.

**Specific aim 1:** to examine the sensitivity and validity of an audio-vocal reaction time dual-task probe paradigm to indirectly measure the changes in attentional demands during acquisition of a goal-directed discrete arm motor skill that consists of distinct movement preparation and execution phases.

**Summary:** This experiment consisted of two groups of participants with mean ages of 28.1 ± 4.9 years were recruited and randomly assigned to either Preparation (N = 11, 5 females and 6 males) or Execution (N = 10, 5 females and 5 males) group. Participants practice an arm task for two consecutive days and returned to the laboratory for a delayed retention test on Day 3. The arm task was a trajectory matching task in which participants replicated the target trajectory by moving a lightweight lever with their dominant arms. The probe task was an audio-vocal two choice reaction time task. Participants either heard the audio stimulus during preparation phase or execution phase of the arm task based on their group assignment. Our results suggested that the audio-vocal reaction time task is a valid and sensitive probe task to measure the changes in attentional demands during acquisition of the arm task. Both groups of participants showed significant decreases in dual-task cost (an index of attentional demands) across two days of practice. This reduction of dual-task cost could not be explained by primary-secondary task trade-off effect or switching task priority during experiment. We have therefore concluded that this dual-task probe paradigm is a valid tool to measure attentional demands during acquisition of the discrete arm task consisting distinct movement preparation and execution phases.

**Specific aim 2:** to determine the effects of type and temporal locus of the secondary probe task on the learning of the primary arm task.

**Summary:** This experiment consisted of five groups of participants mean age of 27 ± 4 years (24 males and 26 females) with a total of 50 participants. They were randomly assigned to:
Control-NoProbe, Choice-Preparation, Simple-Preparation, Choice-Execution, and Simple-Execution groups. Similar to Experiment 1, participants practiced the arm motor task over two consecutive days and came back for a delayed retention test on Day 3. During practice, participants were probed either by a simple or two-choice audio-vocal reaction time task at a probe frequency of 17% based on their group assignment. Those who were assigned to the Preparation groups were probe during movement preparation (500ms before the “Go” signal) before movement started while the Execution groups were probed during movement (300ms after movement started). Dual-task cost (difference in reaction time between baseline and dual task conditions) was used to infer the interference on the dual-task trials. Forgetting (difference in primary motor task performance between immediate and delayed retention tests) was used to assess how well participants learned the primary motor task. Our results suggest that simple reaction time task presented during movement execution resulted in high interference during practice and minimal forgetting during retention. The probe task had minimal influence on the movement preparation phase. We posit two hypotheses to account for the beneficial effects of the simple reaction time task presented during movement execution – vigilance effects and process-specific interference effect, and conducted a follow up experiment to test these two hypotheses.

**Specific aim 3a:** To test which hypothesis vigilance effect or process-specific dual-task interference effect accounts for the beneficial effect of the simple RT task presented during execution phase on motor learning

**Summary:** This experiment consisted of three groups of participants (mean age = 27.7 ± 5.6 years, 11 males and 17 females) and they were randomly assigned to Control-NoProbe, SimpleExecution300ms, and SimpleExecution700ms groups. The tasks and procedures were similar to the Experiment 2 (see Summary of Specific aim 2) except the SimpleExecution700ms group received the probe 700 ms, instead of 300 ms, after movement onset. The results of this experiment support the process-specific interference effect. The SimpleExecution700ms group demonstrated a lower dual-task cost and no motor learning enhancement compared to the SimpleExecution300ms group. The findings indicate that the simple reaction time probe task enhances motor learning of the primary task only when it is introduced at the critical primary task processing timing. Based on these findings, we hypothesized that similar phenomenon would be expected in the preparation phase of the primary task when the choice reaction time probe task is introduced at a critical timing.

**Specific Aim 3b:** to determine whether the enhancement effects of the choice RT task on motor learning would be magnified by presenting the probe task earlier in the preparation phase

**Summary:** We tested three groups of participants in this experiment (mean age = 26.4 ± 3.2 years, 15 males and 16 females) and participants were randomly assigned to 1) Control-
NoProbe, 2) ChoicePreparation500ms, and 3) ChoicePreparation50ms groups. The tasks and experimental procedures were similar to the Experiment 2 (see Summary of Specific aim 2) except that the ChoicePreparation50ms group was probed 50 ms after “Ready” signal (950ms before “Go” signal). The results showed that the ChoicePreparation50ms group had slightly higher dual-task cost during practice than the ChoicePreparation500ms group. The 50ms group also showed significantly less forgetting than the Control-NoProbe group. The findings of this experiment provide further evidence in support of the process-specific interference hypothesis. The choice reaction time probe task enhances motor learning of the primary task when it is introduced at the critical processing preparation timing.

**Aim 4:** to compare attentional demands during execution phase of movement following blocked and random order practice

**Summary:** We recruited 21 participants for this experiment (mean age = 29.1 ± 5.2, 12 females and 9 males). Participants were randomly assigned to Blocked or Random group. The primary motor task was the same arm movement task used in Experiment 1-3, the secondary probe task was a two-choice audio-vocal reaction time task. There were three different versions of the primary motor task; each differed from others in the movement pattern and movement amplitude. The Blocked group practiced the three version of task in a sequential order while the Random group practiced the three versions in a pseudorandom order. The experiment involved two days of practice and delayed retention tests conducted on Day 2 and Day 3. During practice, the Random group showed higher error on the primary task performance and greater dual-task cost than the Blocked group but the differences did not reach statistical significance. In contrast, the Random group showed lower error on the primary task performance and lower dual-task cost than the Blocked group on the retention tests. The findings suggest that the random order practice schedule is beneficial for motor learning and development of automaticity.

**Published abstracts:**


**Manuscripts in preparation for submission:**


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